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AN EVALUATION OF COMPETITIVE PROCUREMENT
METHODOLOGIES APPLICABLE TO THE
ADVANCED ASSAULT AMPHIBIAN VEHICLE

by

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This thesis investigates the types of competition that exist during the different acquisition phases of a weapon system procurement, and discusses the possible effects that competition has on the acquisition cost of these systems. Also, economic, technical, and management variables are presented and discussed that may have a significant impact when considering whether to introduce production competition into a program. Five second sourcing methodologies are presented and discussed with their relative advantages and disadvantages, and a model is presented which allows for a comparison to be performed between the five second sourcing methods. The proposed acquisition strategy for the Advanced Assault Amphibian Vehicle (AAAV) is presented and analyzed as it concerns design and production competition. An analysis of the AAAV program variables is performed, with accompanying economic analysis, which indicates that a Contractor

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An Evaluation of Competitive Procurement Methodologies Applicable to the Advanced Assault Amphibian Vehicle

by

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C.1

ABSTRACT

This thesis investigates the types of competition that exist during the different acquisition phases of a weapon system procurement, and discusses the possible effects that competition has on the acquisition cost of these systems. Also, economic, technical, and management variables are presented and discussed that may have a significant impact when considering whether to introduce production competition into a program. Five second sourcing methodologies are presented and discussed along with their relative advantages and disadvantages, and a model is presented which allows for a comparison to be performed between the five second sourcing methods. The proposed acquisition strategy for the Advanced Assault Amphibian Vehicle (AAAV) is presented and analyzed as it concerns design and production competition. An analysis of the AAAV program variables is performed, with accompanying economic analysis, which indicates that a Contractor Teaming strategy would be appropriate for introducing production competition should the decision be made to second source.

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I. INTRODUCTION

A. GENERAL

Competition in the acquisition of major weapon systems has emerged in the last few years both as a statutory requirement and a major issue in a national debate before Congress and the general public. This situation was brought to the forefront of national attention by many factors, but perhaps chiefly due to the problems of cost overruns and the well publicized cases of questionable pricing by some sole source contractors. This situation did not, however, start in 1988 or even in this century, but was first observed as early as 1794 when Congress authorized the construction of six frigates for the Navy. Of the six frigates authorized, only three were eventually built due to cost increases over the projected costs. In more recent times the cost of Air Force's B-1 bomber, a sole source contract with Rockwell International, rose in the 15 months between January 1981 and March 1982 from $11.9 billion to $25 billion (excluding inflation) [Ref. 1:p. 357]. Also a 1979 General Accounting Office (GAO) report dealing with 58 major acquisitions estimated the total projected costs of the systems to be $235 billion, of which $127 billion had been funded, leaving $97 billion in cost overruns to be funded from future revenues [Ref. 2:p. 11].

Evaluating these figures in light of past, current, and future projected Federal budget deficits provides all concerned parties ample reason to attempt to initiate cost saving measures in weapon system procurement. One predominant reason often espoused by analysts for cost growth is the lack of competition during the development and production of a weapon system. Such competition, it is believed, would act as a catalyst for enhancing both realism in cost projections and cost stability in production.

B. OBJECTIVES OF RESEARCH

The objectives of this study are to: (1) investigate the effects of competition in the procurement of weapon systems, (2) define the types of competition and determine their effect in the procurement process, (3) identify strategies applicable to introducing competition into a weapon system procurement, and (4) evaluate the former as they apply to the procurement of the U.S. Marine Corps Advanced Assault Amphibian Vehicle (AAAV).

C. RESEARCH QUESTIONS

In support of this study's research the following major research question was posed: How might competitive procurement methodologies be incorporated in the Advanced Assault Amphibian Vehicle program's acquisition strategy?

To answer this question, the following subsidiary questions were addressed:

1. What is the AAAV program's acquisition strategy at this time?

2. What are the competitive procurement methodologies which could be employed in the AAAV program?

3. What are the variables that must be considered in evaluating, formulating and executing a competitive procurement strategy?

4. If competitive procurement can be employed, what method(s) will deliver the maximum benefits to the program of lower price and higher quality?

D. RESEARCH METHODOLOGY

The information presented in this study was obtained from (1) currently available procurement literature, and (2) interviews with contracting personnel currently involved with programs utilizing competitive procurement methodologies. Literature references were obtained from material held at the Naval Postgraduate School, the Defense Logistics Studies Information Exchange (DLSIE), the Defense Technical Information Center (DTIC), and the Department of Defense (DOD) Directives and Instructions applicable to this study. Interviews were conducted both via telephone and in person and are identified in the references.

E. SCOPE OF STUDY

The scope of this study is in the form of a case study, and ascertains the feasibility of competitive procurement of the AAAV. This study addresses present methods of competitive procurement and evaluates their applicability in the AAAV program. In evaluating competitive procurement

methodologies other programs have been reviewed to determine if the lessons learned from them can be applied to the AAAV program.

F. LIMITATIONS

Though this study addresses lessons learned from other programs, it will not attempt to critique the programs implementation of a particular methodology. Rather it will extrapolate similar circumstances and criteria from previous efforts and attempt to apply a programs results in predicting the most likely outcome if utilized in the AAAV program.

G. ASSUMPTIONS

It is assumed that the reader of this study has a familiarity with the basic concepts and regulations pertaining to systems acquisition.

H. ORGANIZATION OF THIS STUDY

Chapter II of this study presents an overview of the nature of competition, discusses the types of competition, the factors affecting the use of competition, and provides a basis on which the study will build an analysis of the possible effct of competition of the AAAV program. Chapter III will introduce the dual sourcing methodologies and presents the advantages and disadvantages of each method. Chapter IV will focus on the effects of cometition on the Automotive Commodities of which the AAAV is a member, and presents a basis for evaluating the potential benefits of

competition and the risks of foregoing competition. Chapter V presents the current acquisition strategy of the AAAV program and analyzes the strategy's use of competition throughout the acquisition process. Chapter VI analyzes the individual variables that must be considered in evaluating the relevance of introducing production competition, and analyzes the suitability of each dual sourcing method for use by the program. Chapter VII presents a method for performing an economic analysis of the effect of dual sourcing on funding for the program. This method is then applied in analyzing the recommended dual sourcing methodology and possible economic projections are presented. Chapter VIII presents recommendations and conclusions of the study.

II. AN OVERVIEW OF COMPETITION

A. INTRODUCTION

Increased competition in the acquisition of weapon systems has been hailed by many as one possible solution to the numerous and well publicized problems surrounding Government procurements. Besides the well founded belief that competition will result in lower prices, other benefits include improved quality and reliability, technical innovation in addressing new requirements, the expansion of the industrial base, and the appearance of safeguarding the public trust in the awarding of contracts and commitment of public funds.

Congressional preference for competitive procurement methods have been plainly expressed in both Public Law and Department of Defense (DOD) Directives. These include:

1. Competition in Contracting Act (CICA) of 1984 (Public Law 98-369). CICA strongly affirms that competition is the standard acquisition method and that sole source procurement is the exception.

2. Office of Management and Budget Circular A-109. Places emphasis on the early stages of the acquisition process allowing competitive exploration of alternative system designs that will meet the mission need.

3. DOD Defense Appropriations Act of 1984 (Public Law 98-212) states:

   None of the funds made available by this Act shall be used to initiate full-scale engineering development of any major defense acquisition program until the Secretary of Defense has provided to the Committees on Appropriations of the House and Senate:

a. a certification that the system or subsystem being developed will be procured in quantities that are not sufficient to warrant development of two or more production sources, or

b. a plan for the development of two or more sources for the production of the system or subsystem is being developed.

4. SECNAVINST 4210.6A of 13 April 1988. Requires that:

The development of each project/program will begin with a minimum of two contractors/contractor teams performing concurrent but separate development up to full-scale engineering development at which time it will normally be narrowed to two contractors developing a system to one design.

5. DOD Directive 5000.1 states:

That provisions for obtaining competition in each phase of the acquisition process shall be described in the acquisition strategy. This includes planning for competition for ideas and technologies in the early phases and the use of commercial style competition procedures that emphasize quality and establish performance as well as price during the production phase.

In summary, a program manager is required by law and regulation to actively pursue competition to the greatest extent possible during all phases of the acquisition process. As will be shown the accomplishment of this goal will depend largely on the decisions and evaluations performed early in the acquisition planning process. Ground lost early in the process may prove difficult or impossible to regain due to a contractor's prohibitive pricing of technical data or the previous elimination of possible competitors.

B. EFFECTS OF COMPETITION

In 1965, then Secretary of Defense McNamara testified to the Joint Economics Committee of Congress that competitive

procurement of DOD systems could save the country 25% of the total cost of a systems procurement [Ref. 3:p. 17]. Though this figure lacked substantiation, an emphasis on competitive research since that time has produced empirical evidence that supports the claim that substantial savings may be realized when competition is introduced into the procurement process. The results of several such studies, conducted by the Institute for Defense Analysis (IDA), the Army Procurement Research Office (APRO), and The Analytical Services Corporation (TASC) are shown as Table 1 [Ref. 4:pp. 1-20, 1-21]. The different figures, reflecting the computed amounts of savings, are due to dissimilar research methodology and structure. The savings reflect only recurring costs and not the nonrecurring costs associated with gaining competition (i.e. special tooling).

One interesting observation of the IDA-74 study was that the original source won only one of the subsequent 17 winner-take-all competitions. Two reasons put forward to explain this fact are: [Ref. 5:pp. 48-49, 6:p. 20]

1. That the original source utilized manufacturing labor over capital investment, even though this sacrificed efficiency, since under the profit policy this strategy would generate greater profits. This arrangement caused the manufacturer to be trapped by his own inefficiency.

2. That the original source felt that it could not greatly reduce the offered price because it felt compelled to support past pricing practices.

TABLE 1

ESTIMATED PERCENTAGE SAVINGS DUE TO COMPETITION

Equipment	IDA-74	APRO-78	IDA-79	TASC-79
Electronics				
FAAR Radar		16.6		16.6
FAAR TADDS		18.2		18.2
AN/ARC-131		-2.1		-16.2
UPM-98 Test Set		3.0		11.5
TD-352 Multiplexer	57.8		58.0	55.6
TD-660 Multiplexer	30.2		38.3	28.4
60-6402 Elec. Cont	57.0		49.4	52.7
SPA 66 Radar Ind.				-3.4
APX72 Airb. Transp	32.6		27.1	23.3
AN/ARC-54			55.0	63.1
AN/ARC-77		34.8	20.5	41.9
AN/GRC-106			43.3	41.8
AN/GRC-103			58.7	60.1
AN/APM-123			61.2	67.7
SPA-25 Radar Ind.	21.3		48.8	10.7
USM-181 Test Set	36.0		56.0	36.3
FGL-20 Teletype	32.0		23.7	39.9
MD-522 Mod/Demod	60.3		58.6	51.9
AN/ARA-63 Radio				57.9
AN/SQS-23 Transd.				32.2
Missile/Components				
Tow Missile	48.1	8.5	8.9	12.3
Dragon Round		2.7		2.8
SHILLELAGH	-0.2	5.9	-8.0	9.4
TALOS (G&C unit)	42.3		40.8	39.8
BULLPUP 12 (Martin)	13.9		31.7	26.5
BULLPUP 12 (Maxson)	45.8			
SIDEWINDER AIM-9D/G			-4.6	0.7
SIDEWINDER AIM-9B			1.6	-5.6
STD. MISSILE 66A			-4.2	59.2
STD. MISSILE 67A				34.0
Equipment				
HAWK Motor Parts	6.4		45.7	49.9
TOW Launcher		30.2	44.2	30.2
DRAGON Tracker		12.0		12.3
MK-48 Torpedo Wrhd.	53.2			48.6
MK-48 Elect. Ass.	37.5			47.0
MK-48 Exploder				61.8
Rockeye Bomb			-23.0	-4.5

Source: Establishing Competitive Productive Sources, 1984.

C. PERFECT COMPETITION VS. EFFECTIVE COMPETITION

Economist have classified competition in the market place into four categories: perfect competition, monopoly, monopolistic competition, and oligopoly. The deciding factors in each of these classifications are the number of buyers and sellers in the market; a) perfect competition has many buyers and sellers, b) monopoly has one seller and many buyers, c) monopolistic competition (monopsony) has a single buyer and many sellers, and d) oligopoly where a small number of firms, sharing great interdependence, make up the market with many buyers (i.e., oil industry). [Ref. 7:pp. 231-232]

For perfect competition to exist and exert pressure on the market to produce efficiently (at the lowest possible cost), four conditions must exist: [Ref. 7:p. 232]

1. There must be many buyers and sellers so that the product of any one seller is the same as the product of any other seller.

2. Each participant in the market, whether buyer or seller, must be so small in relation to the entire market, that it cannot effect the producers price.

3. That all resources be completely mobile and free to move into and out of the market at will.

4. Consumers and sellers have perfect knowledge of the relevant economic and technical data.

The configuration of the defense market is such that none of the above criteria will be fully met for the vast majority of items procured. Appendix A presents a comparison of the differences faced by the buyer and seller between the defense

market and the commercial market [Ref. 8:pp. 16-18]. With the specialization of technology and defense contractors carving out special niches in the market the program manager faces a competitive category known as "bilateral monopoly". This is a market characterized by a single buyer confronted by a single seller (Sole Source Environment). In the bilateral monopoly the Government finds itself as the only buyer (monopsonist), and since most weapon systems are sufficiently unique from others the seller finds itself in the position of a monopoly. In this market the price that is finally paid for an item is determined by the relative bargaining strengths of the two parties and the skill of their negotiators. [Refs. 5:p. 40, 7:p. 296]

The objective of the Government when confronted by a bilateral monopoly is to introduce competition into the market by locating or developing an additional source(s) which will be able to compete effectively with the original seller and thereby introduce competitive pressures into the acquisition process. If successful, a market with two sellers is established in which they compete for the buyer´s market. This type of market is called a "duopoly". The existence of a duopoly leads to the concept of effective competition. Effective competition is defined as "that as the result of competition, the expected value of the benefits realized exceeds the expected value of the costs." [Ref. 9:p. 21] The goal of competitive procurement then is to introduce

effective competition into the market and to lower the acquisition cost sufficiently to achieve at a minimum the recovery of costs incurred by the Government in establishing a second source. [Refs. 5:p. 40, 7:p. 334]

The existence of the duopoly, however, as has been demonstrated in defense procurement does not in itself guarantee that competition between the two sources will be effective. It is accepted in the duopoly that both firms will attempt to maximize their respective profits in relation to other business/products that the firm manufactures. Each firm also possesses a limited amount of resources which it may utilize to make investments. If a firm concludes that it can maximize its profits by manufacturing other nondefense products and does not devote sufficient resources to compete fully against its competitor in the defense market, it will assume a follower role. In the duopoly then, four possibilities exist for competitive interaction: [Ref. 5:p. 41]

1. Firm A decides to be the leader and Firm B follows.
2. Firm B decides to be the leader and Firm A follows.
3. Both firms desire to be the leader.
4. Neither firm desires to be the leader.

Only in the third example will true competition surface. Since dual sourcing efforts require two manufacturers, it is possible for a firm to utilize a price gaming strategy in which it will satisfy itself with the award of the sustaining

rate portion of production at a price designed to maximize its total corporate profits. This gaming guarantees the losing source a prescribed production quantity at its price, and allows the firm to maximize total corporate profits but without introducing substantial competitive pressure on price. This price gaming is one factor that makes the accurate forecasting of savings due to competition difficult; because no one can tell, if or when, price gaming may enter the market. [Ref. 7:p. 335]

D. DESIGN VS. PRODUCTION COMPETITION

In the process of awarding a contract, a program manager is concerned with two types of competition, Design/Technical and Production/Price.

1. Design/Technical Competition

Design competition is defined in DFAR 4.6-16(B) as:

> Design or technical competition is present when two or more qualified sources of supply are invited to submit design or technical proposals, with the subsequent contract award based primarily on this factor, rather than on a price basis.

The primary goal of design competition is to identify and develop different conceptual/technical approaches that fulfill an identified mission need while falling within an affordable price range. This competition occurs predominantly during the preliminary phases of the acquisition process. The scenario for this competition is generally in line with the award of multiple (three or more) contracts during the Concept Exploration (CE) Phase, leading

to a down selection to multiple (two or more) contracts in the Demonstration and Validation (D&V) Phase, and finally to the award of a contract to one or two finalists entering into Full Scale Development (FSD) with a single design. Figure 1 demonstrates the above description of design competition [Ref. 4:p. 1-9]. [Ref. 4:p. 1-8]

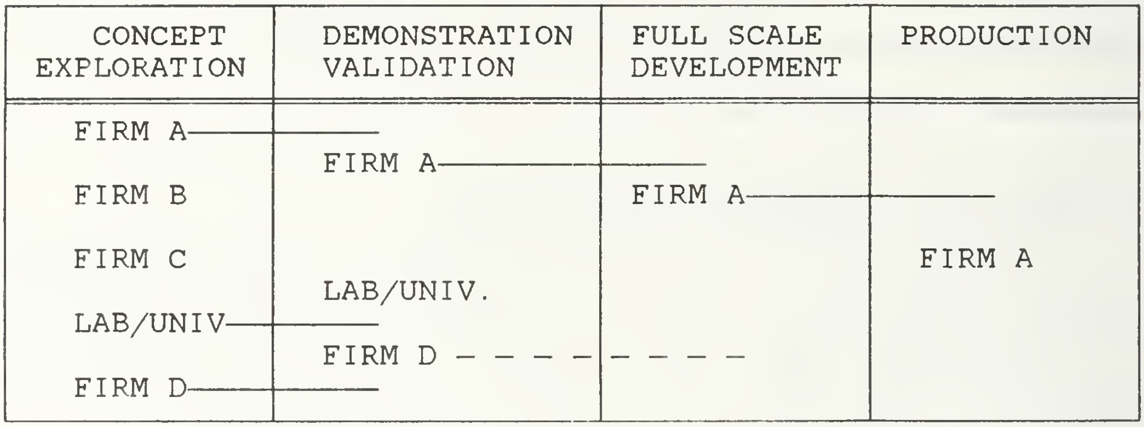


Figure 1. General Format of Design Competition

Source: Establishing Competitive Production Sources, 1984.

2. Production/Price Competition

Production competition may take place during FSD but occurs predominantly during the production phase of the acquisition process. DFAR 4.6-16(d) defines production/price competition as:

> A contract shall be reported as "price competition" if offers were solicited and received from at least two responsible offerors capable of satisfying the Government´s requirements wholly or partially, and the awards or awards were made to the offeror or offerors submitting the lowest evaluated prices.

The goal of production competition is to procure the system at a "fair and reasonable price", to continue to encourage quality and technical improvements, and to expand the industrial base for use in the event of full mobilization or surge requirements. In contrast to design competition, which was concerned with projecting a realistic price, production competition is concerned with ensuring a fair and reasonable price. During production, however, the contractor´s primary concern is with the profit earned from making the weapon system. It is during production in the sole source environment that the Government may see the cost of a system rising and find that it has little or no leverage to inhibit cost escalation. Production competition has been found to be the most effective method the Government possesses for ensuring that the price paid for the system is fair and reasonable. [Ref. 4:p. 1-15]

3. Carry Over Theory of Competition

The design and production competition processes are separate, unique components of the acquisition cycle. Some researchers have suggested that intense design competition will subsequently lead to effective production competition. This hypothesis, know as the "carry-over theory" has little support in practice [Ref. 9:pp. 19-20]. During design competition contractors are primarily concerned with maintaining a viable competitive position, and hopefully winning the eventual production contract and securing the

profits from this effort. Though design and technological factors and not price are assumed to be the key concern in design competition, both the contractor and program manager are aware that a smaller price tag is an inducement for a concept to be carried forward into the next acquisition phase. This inducement has caused many contractors to be overly optimistic in their price forecasting and can lead to price increases once in production. This hypothesis has also been found to be true when only one concept is carried forward to FSD and development price estimates grow as unforseen and unanticipated changes or problems are encountered [Ref. 4:p. 1-10]. [Ref. 9:p. 16]

The absence of competition in future acquisition phases then tends to increase the "buy-in" efforts of contractors. This bidding strategy is based on the belief that the contractor will have ample opportunities to "get well" during later sole source acquisition phases. In addition program managers, who naturally have a strong interest/attachment for the program and are program advocates, are induced not to vigorously challenge cost projections during design competition. If a single contract is carried forward to FSD and technical problems occur, the Government has lost the leverage it possessed in a competitive environment and may find contract costs rising excessively. Also the "winner-take-all" position typically present when awarding a single contract entering FSD,

pressures the contractor to be very optimistic since this may be the end of the line with the resultant loss of production opportunities. [Ref. 10:p. 19]

E. FACTORS AFFECTING PRODUCTION COMPETITION

The decision to dual source a system and introduce a new production source is often a complex economic, technical and management decision. As previously mentioned, this decision is practiced generally when the sum of the total recurring cost savings is greater than the sum of the nonrecurring costs needed to establish the second source. The decision to introduce a second source when the above criterion is not valid is usually attributed to political, socioeconomic, or other factors.

1. Economic Variables

a. Quantity to be Procured

A general rule is that the larger the quantity procured, the greater the potential for production competition [Ref. 4:p. 3-1]. A larger production quantity allows for a smaller allotment of nonrecurring costs to each item produced (amortization), allows a smaller savings margin from a flatter progress curve to accumulate to recover the costs of establishing the second source, and increases the opportunity for learning to progress and lower the unit cost. [Ref. 11:p. 107]

b. Production Duration

Producers are generally attracted to more lengthy, stable programs because they offer an attractive market with fewer problems and less possibility of program cancellation. Generally the longer the production duration, the more favorable the outlook for competition. [Ref. 11:p. 107]

c. Special Tooling and Special Test Equipment

The establishment of a second source for production may largely depend on the amount of this single factor. Given the unique characteristics of defense systems a manufacturer may require large investments in special tooling and special test equipment that is unique to a specific type of production effort. These costs will have to be amortized over the quantities produced, and generally represent the major nonrecurring cost of establishing the second source. It has been observed that these requirements vary considerably from commodity to commodity. [Ref. 4:p. 3-3]

d. Learning Curve

Also known as the Price Improvement Curve (PIC) or Progress Curve, this concept develops a relationship where the price of the Xth. unit produced will be reduced by a demonstrated percentage as the number of units produced doubles. Where a 95% learning curve is relevant, the cost of the second unit would be 95% of the first, the fourth unit

would be 95% of the second, the eighth unit would be 95% of the fourth, and so on. Generally the more shallow the learning curve, i.e., 95%, the greater the potential for savings from the shift and rotation of the learning curve. If a steep curve is present, i.e., 75%, the original producer may have moved substantially down the learning curve and reached a point where the second source would not be able to compete effectively due to the significant learning experienced by the original source. [Ref. 4:p. 3-3]

The anticipated savings from production competition result from an observed shift and rotation of the progress curve once competition is introduced, or once the threat of competition is considered viable by the first source. Figure 2 demonstrates the concept of the shift and rotation of the progress curve. Initially, a shift in the progress curve is experienced due to the introduction of competition and delivers immediate savings, secondly, a rotation/steepening of the progress curve delivers an increased level of learning and subsequent savings as competition continues into future years as the competitors vie for production awards. The savings that result from production competition are the difference between the anticipated cost of the program following the original progress curve, minus the projected cost of production considering the expected shift and rotation of the progress curve, minus the cost of establishing the second source.

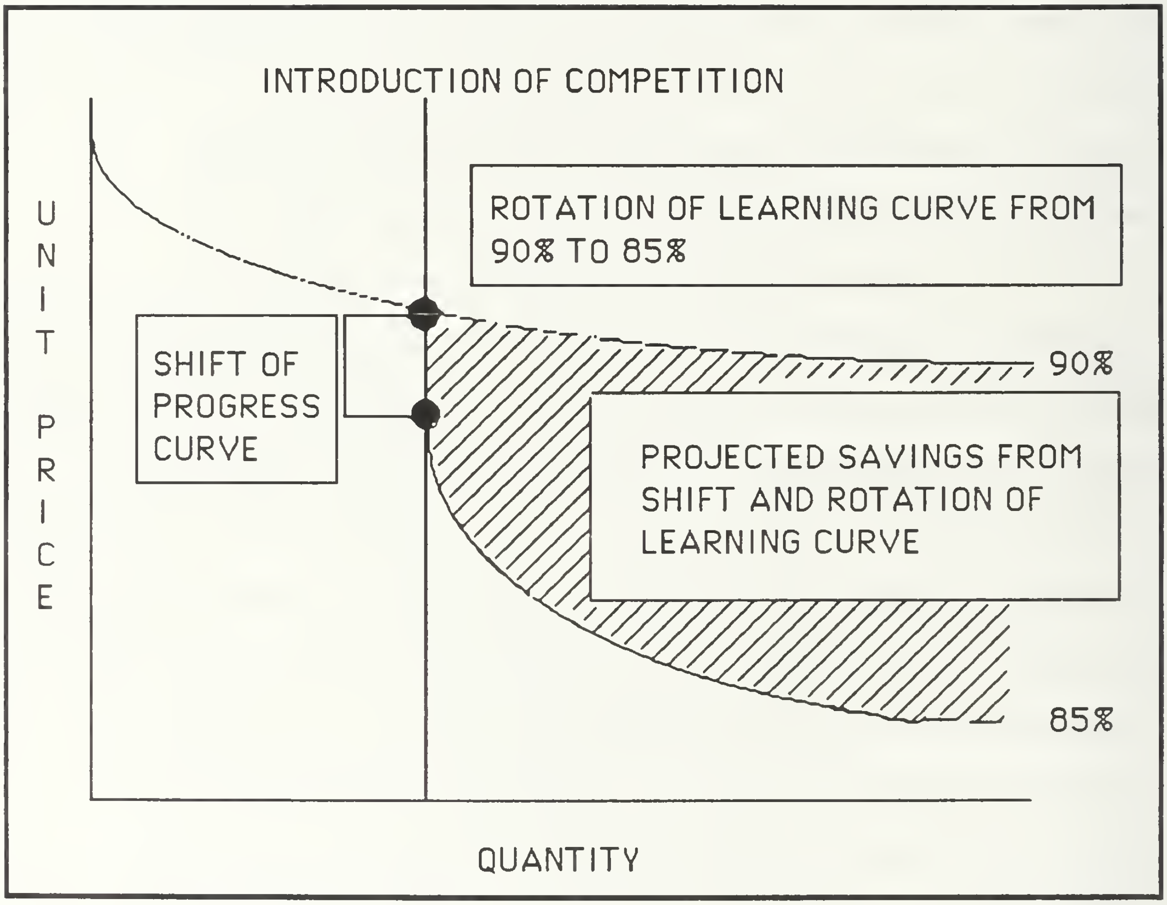


Figure 2. Projected Savings from the Shift and Rotation of the Learning Curve

Source: Developed by the Researcher.

The concept of the shift and rotation of the progress curve can be better appreciated and analyzed in Figure 3 which presents the recorded effects of competition on the acquisition of the Tomahawk Cruise Missile. In the case of the Tomahawk, General Dynamics (GD) as the sole source demonstrated a 93% progress curve during the initial four years of production. After the completion of the technology transfer with Raytheon as the second source, GD offered price reductions for the missile which represented a 35% shift, and a 2% rotation of the progress curve from 93% to 91%. Even before competition was introduced, GD offered price reductions for the missile as shown in their offer for a multiyear contract. As shown in Figure 4 competition in the procurement of the missile is expected to generate total savings of $768 million with procurement of 100% of the planned buy. If competition had not been introduced, projections indicate that insufficient funds were available in the budget to procure all the rounds desired by the Navy. [Ref. 12]

e. Contractor Capacity

This variable is concerned with production rate. The production rate of a commodity is the level/rate at which an item is produced over a given time span, i.e., 100 units per month. If the rate at which the system is to be procured exceeds the production capacity of the sole source, then additional production capacity will be required from either

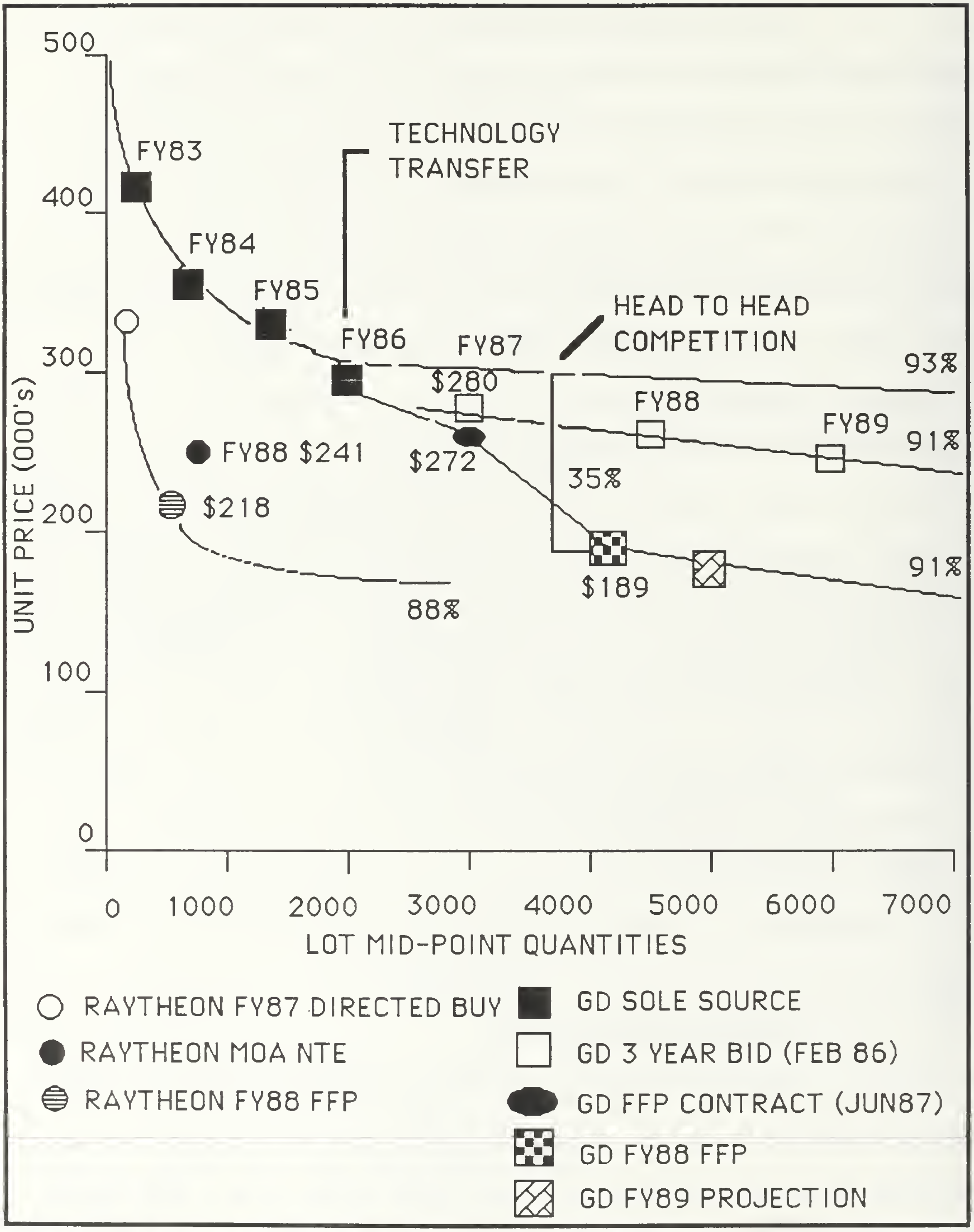


Figure 3. Effect of Competition on Pricing of the TOMAHAWK Cruise Missile

Source: Office of the Assistant Secretary of the Navy (Shipbuilding & Logistics)

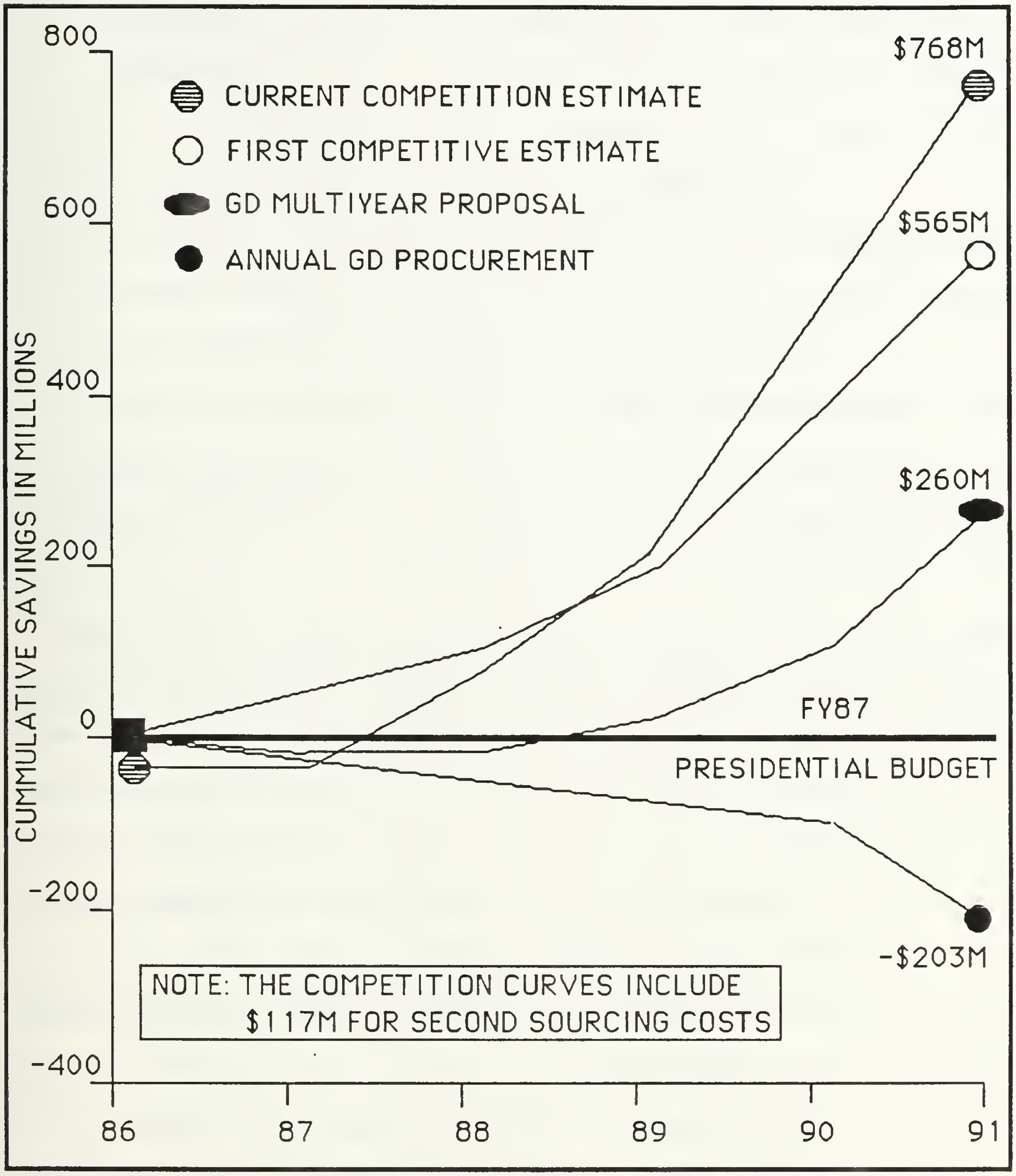


Figure 4. Projected Savings from the Competitive Procurement of the TOMAHAWK Cruise Missile

Source: Office of the Assistant Secretary of the Navy (Shipbuilding & Logistics)

the original source or a competitive source. The decision to compete a system is generally simpler when capacity is insufficient for the contract. [Ref. 9:p. 55]

The presence of excess contractor capacity may affect the competitive decision in two ways. First, if excess capacity is present the loss of production due to splitting awards may increase overhead rates on each unit. This would raise the price of units produced from the original source. Second, the impact on production rate is directly related with the concepts of "economy/diseconomy of scale" and the "law of diminishing returns" [Ref. 7:p. 198]. The concept of economy of scale states that production costs for an item when graphed are generally "U" shaped (Figure 5), with the minimum cost associated with point "E", the maximum cost at points "1" and "2E-1", with the minimum and maximum production rates at "1" and "2E-1" respectively [Ref. 7:pp. 226-227]. The production rate cost curve demonstrates that the costs associated with the production of an item may decline or increase depending on the original position of the manufacturer on the curve.

The production rate cost curve is "U" shaped because the first unit produced must bear the full burden of all fixed costs of production with subsequent units incrementally reducing that burden until achieving the most efficient level of production (Point E). Further investments of capital, labor, or material will increase production but

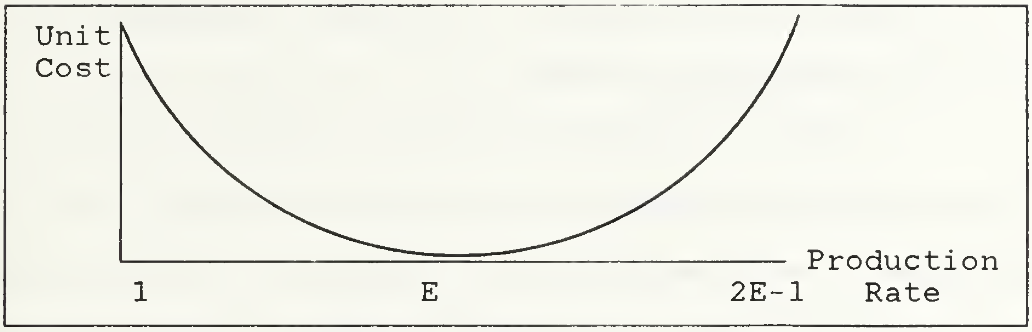


Figure 5. Production Rate cost Curve

Source: Microeconomics: Theory and Applications, 1985.

at a diminishing marginal return for investment beyond point "E" due to the Law of Diminishing Returns which states that: [Ref. 7:p. 159]

> If equal increments of an input are added, the quantities of other inputs held constant, the resulting increments of product will decrease beyond some point, the marginal product of the input will diminish.

Some of the added cost that may cause this decrease in marginal product return beyond Point E include overtime for workers and increased maintenance for machinery.

The situation could present itself where the contractor has sufficient capacity for the proposed contract increase, but be operating at a point on the curve such that the contract would require production at rates well above the efficient use of capacity. In this case it could prove more economical to add a second source.

2. Technical Variables

a. Proprietary Data

The Government´s right to technical data pertaining to the design of the actual item and the manufacturing processes involved has the potential of being a major obstacle to second sourcing. If the Government fails to procure unlimited rights to patent/proprietary data a second source may not be feasible technically or financially. The rights to utilize all necessary data should be negotiated early in the procurement process. It may prove impractical to procure these rights at a later time when the contractor can be expected to prohibitively price these rights in an effort to prevent competition.

The importance of this variable was well demonstrated on the second sourcing of the cruise missile engine. When the second sourcing effort began, the developer originally claimed 100% of the parts as proprietary data which necessitated the use of a Directed Licensing approach. This required the payment of royalties for use of the data by the second source to the developer which resulted in additional cost to the Government. Due to the urgency of the contract, the Government was not able to verify the claim. After several years of legal clarification and investigation the developer now only claims rights to six parts. This amounts to less than one per cent of the original claim. [Ref. 11:p. 110]

b. Technical Complexity

The technical complexity of a system may dictate the use of more elaborate and expensive data transfer methods, i.e., Leader-Follower, and may make infeasible the implementation of a Technical Data Package (TDP) strategy due to the difficulty in preparing the TDP. [Ref. 4:p. 3-4]

c. State-of-the-Art

A state-of-the-art system may proof difficult to compete. These systems have a higher rate of change than mature systems which increases the difficulty of acquiring a useful TDP. This variable may also dictate the use of face-to-face contractor assistance to effect technology transfer. [Ref. 4:p. 3-5]

d. Other Applications

If the system has commercial potential the likelihood for competition is increased [Ref. 4:p. 3-5]. This reflects the increased size of the potential market and the ability to sell to customers outside the Government market. Even if the system itself is not suitable for commercial marketing, the use of production processes that can be applied to other commercial endeavors increases the possibility of competition.

e. Privately Funded Research and Development

The development of modern weapon systems often entails a combination of Government and private funding. The rights to data acquired through private development belong to

the developer and may not be used without compensation or permission. The presence of proprietary data may prohibit or impede competition. [Ref. 4:p. 3-5]

3. Program Variables

a. Maintenance Requirements

The second sourcing of a system may entail fielding two systems that perform identically, but do not use the same maintenance parts or procedures. As part of the second sourcing decision the maintenance philosophy of the system must be reviewed to ensure that supportability of the system is not jeopardized. [Ref. 11:p. 108]

b. Production Lead Times

The existence of long production lead times for critical components may delay production competition even though a second source is qualified, because the second source cannot acquire components needed for production [Ref. 4:p. 3-6]. This delay may make competition less attractive or impossible. Typical lead times for such components as aluminum forgings and aircraft landing gears, which may both require up to 120 weeks, indicate the potential of such problems [Ref. 11:p. 109].

c. Degree of Subcontracting

If large amounts of subsystems are subcontracted competition may not deliver its full benefits for two reasons. First, the prime contractor(s) would not have direct control over the costs of production; and secondly,

for certain critical/specialty systems the two production sources could find themselves in competition for the limited quantity available. This would require them to bid for the subsystem and result in higher prices. Since it is unlikely that the market could react quickly enough to overcome this situation it would reduce the benefits expected from second sourcing. [Ref. 4:p. 3-6]

d. Contract Complexity

The more complex the original contract is, the greater difficulty in establishing competition. The existence of warranties, the use of complex cost type contracts, award fees, and other incentives may not be compatible with provisions required for establishing the second source. [Ref. 4:p. 3-6]

F. THE THREAT OF COMPETITION

In negotiating or performing a contract with a sole source the program manager may decide to use the threat of possible competition in future contracts as leverage in gaining favorable concessions from the contractor. The concessions gained utilizing this strategy are directly related to whether the contractor considers the threat genuine [Ref. 6:p. 25]. In negotiating, one is dealing in the realm of uncertainties and "what ifs". In this circumstance the program manager is using the power to introduce competition into the acquisition process as leverage. Also in negotiating all power/leverage is

relative; this means that the way the contractor perceives the threat, viable or unlikely, determines the reaction that can be expected. An example will demonstrate this concept.

In the case of Amron Inc., the contractor had been making the M103 brass cartridge for several years under a sole source contract. Then in 1978, after the Government´s repeated inability to gain price concessions from Amron, the company lost a winner-take-all competition to National Eastern Corporation. Immediately Amron offered a significant price reduction on a production option under the present contract, a 27.7% reduction in price from 60.72 cents to 43.93 cents per cartridge. [Ref. 6:p. 25]

Figure 6 will assist in explaining how the threat of competition can influence the pricing strategy a firm might employ. The vertical line (d) represents the point at which competition is expected to be introduced into the procurement and demonstrates the shift and rotation of the learning curve as theorized in a competitive model. Line (b) reflects the competitive price in the market and is viewed as "fair and reasonable" for the effort and risk. In the absence of competition a firm can be expected to price the contract between lines (a) and (b). This illustrates a "skimming" or a profit maximizing pricing strategy. This pricing reflects a lack of competition in the market and as shown is priced above the line reflecting a competitive price. If competition is viewed as a certainty a firm may price a

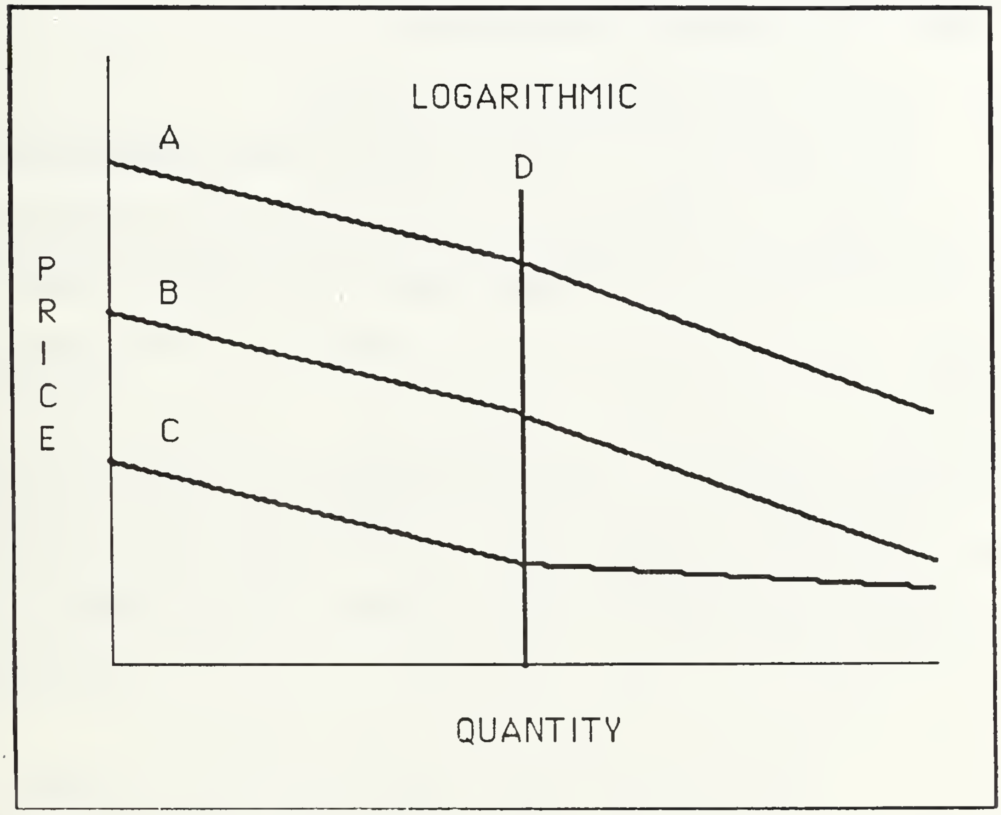


Figure 6. Effect of the Threat of Competition on Pricing Strategy

Source: Evaluation of Models and Techniques for Estimating the Effects of Competition, 1986.

contract between lines (b) and (c). This illustrates a "penetration" pricing strategy and may be employed to discourage competitors from entering the market. The result though is that the threat of competition, if viewed as genuine by a contractor, can influence the attitude and manner in which he prices/bids a contract. [Ref. 6:p. 24]

G. TYPES OF PRODUCTION COMPETITION

1. Split Buy/Sustaining Rate Awards

The term "split buy/sustaining rate" award refers to a guarantee by the Government to a contractor, involved in the dual sourcing of a system, that if its bid for the contract is not accepted as the lowest/prime source it will nevertheless be awarded a contract for a smaller sustaining portion of production. This sustaining portion is generally established as a percentage of the quantity to be produced, i.e., 25%, during the current contract. This award results from the decision of the Government to maintain dual sources in future production to keep open the prospect of competition. Due to the unique characteristics of DOD weapon systems, it is inconceivable that a firm would choose to maintain a production capability and bear the added expense when no market exists for its product. The sustaining award provides a market for the minimum production quantity sufficient to maintain the second source. [Ref. 4:p. 14-2]

2. Winner-Take-All Award

As the name implies the "Winner-Take-All" award of a contract assigns to the winning contractor the full production quantity of the contract. It has been observed that this type of award increases the projected cost savings of the contract by eliciting a reduced price for the effort. Several reasons seem plausible and support this observation: [Ref. 6:p. 25]

1. Winner-Take-All does not sacrifice economy of scale the way dual sourcing must.
2. The splitting of a production quantity between two sources reduces the learning effect that eventually results in potential savings.
3. There is no second place or tomorrow in winner-take-all awards.
4. Due to the unique characteristics of weapon systems and the costs of keeping facilities idle, it is doubtful that a contractor will be available or capable of production in the future once a contract is lost. This fact necessitates a true "best and final offer" to attempt to secure the contract. The exception to this point are those items for which a commercial market exists.

Figure 7 displays the estimated savings by competition type as reported by TASC 79. [Ref. 6:p. 16]

H. SUMMARY

This chapter introduced the concept of competition and presented research that substantiated the claim that a competitive environment could reduce the acquisition cost of weapon systems. In discussing competition, this chapter also

differentiated between the concepts of effective competition and perfect competition, and discussed the variables that may have an impact on the decision to introduce competition. Also the differences between design and production competition were introduced and an appreciatiion of the merits of each was discussed.

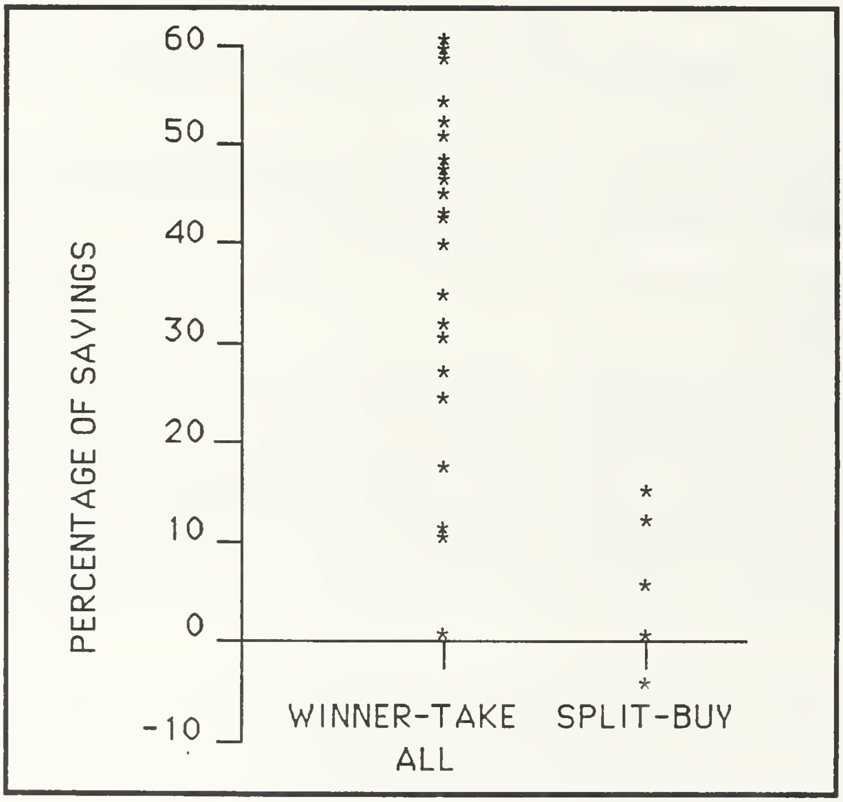


Figure 7. Production Award Method Savings Comparision

Source: Evaluation of Models and Techniques for Estimating the Effects of Competition, 1986.

III. AN INTRODUCTION TO SECOND SOURCING

A. GOALS OF SECOND SOURCING

A basic management tenet is that a business/program must establish goals and work towards these goals to succeed in its mission/purpose. The two basic goals of a second sourcing effort are: [Ref. 2:p. 22]

1. To control or reduce the cost/price of an item.
2. The maintenance of an adequate industrial base.

In addition several other collateral goals may be realized that benefit the program and the country: [Refs. 2:p. 22, 13:p. 5-3]

1. Improved mobilization capability.
2. Promote geographic dispersion of industry so as to preclude destruction of an only source due to natural disaster or enemy/terrorist attack and qualify new sources who possess specialized technologies.
3. Smooth out fluctuations in production for individual firms caused by sole source awards.
4. Needed Government controls are lessened due to the presence of competition.
5. Increase technical performance by increasing technical or design competition.
6. More fully meet socioeconomic goals by increasing awards to minority and small/disadvantaged businesses.
7. Increase ability to meet commitments of co-production agreements for NATO programs.
8. Obtain a higher quality product.
9. Encourage the incumbent to be more receptive to the concerns of the buyer and to address criticisms.

The advantages presented clearly show the potential benefits of second sourcing. Each factor should be considered during the economic analysis of the second sourcing decision and given the weight that each may warrant under the existing situation.

B. TECHNICAL DATA RIGHTS

Before discussing the methodologies utilized in implementing the second sourcing of a system it is important to understand the concept of technical data rights. The determination of the Government's right to data is perhaps the single determining factor in deciding on the methodology employed in second sourcing. There are two basic types of data rights: [Ref. 13:p. 5-18]

1. Unlimited Rights. The right to use, duplicate, or disclose technical data in whole or in part in any manner and for any purpose whatsoever, and to direct or permit others to do so.

2. Limited Rights. The right of the Government, or others on behalf of the Government, to use duplicate, or disclose data, but not outside the Government without written permission.

FAR 27.406.d(4) states that it is the general policy of the Government to acquire data with unlimited rights when the data resulted from work on a Government contract. When the data is developed in independent research and development efforts conducted by a contractor the data and its use are controlled by the contractor. Contractors consider such data proprietary and have shown a historic tendency to restrict its use to maintain market share or competitive edge.

A new type of technical data right called "Government Purpose License Rights (GPLR), is just now being introduced during the writing of this study. This new classification of data rights has as its goal the clarification of the authorized use of technical data, when the data resulted from work funded by both the Government and the contractor. This new concept became effective in DOD FAR Supplement Subpart 227.471 on 4 April 1988 and is defined as:

> Rights to use, duplicate, or disclose data, in whole or in part and in any manner, for Government purposes only, and to permit others to do so for Government purposes only. Government purposes include competitive procurement, but do not include the right to have or permit others to use technical data for commercial purposes.

The adoption of the GPLR concept will protect the legitimate rights of Government contractors to technical data, which could be used by competitors in commericial markets. This is accomplished while simultaneously allowing the Government to use the technical data to introduce competitive pressure into the defense market, by transferring the data to other potential contractors, without the timely and costly delays associated with challenging data rights.

When introducing a second source, determining the Government´s rights pertaining to the use of data is a mandatory step in the decision process. Since most data are Department of Defense unique and developed in whole or in part at Government expense, the Government maintains unlimited rights. In cases where data are proprietary, the Government evaluates the program implications of buying the

rights, or in arranging to use the rights in a limited manner if the contractor refuses to sell them. Practice has shown that data rights can be easily negotiated during design competition when competitive pressure assists the Government in negotiating a reasonable price for the data. The DFAR (27.403-2(f)) lists the conditions when the Government may negotiate for unlimited rights in proprietary data:

1. There is a clear need for reprocurement of the item.
2. There are no suitable alternative items or processes.
3. The item can be manufactured by a competent manufacturer without the need for additional data that cannot be reasonably purchased.
4. Savings in reprocurement using the purchased data will exceed the data cost and rights-therein.

C. SECOND SOURCING METHODOLOGIES

Once the decision to second source a system is made, the program manager must decide on how to bring this effort to a successful completion. This process is a complicated managerial and technical effort requiring high skill, coordination, and supervision. Practice has identified five strategies or methodologies currently used to accomplish the second sourcing effort. These methodologies are Form, Fit and Function; Technical Data Package; Leader-Follower; Direct Licensing; and Contractor Teaming. [Ref. 11:p. 22]

1. Form, Fit, and Function (F3)

The F3 method of second sourcing depends on a second source designing an acceptable alternative system that meets

established performance specifications (speed, accuracy, or a specified ability) and physical specifications (size, weight, length). F3 lends itself most readily to simple components such as ammunition, but has been successfully introduced in very complex and expensive systems such as the Air Force's Alternate Fighter Engine Program [Ref. 10:p. 96]. Where the system is a subsystem of another major end item, the F3 method prescribes that the system must meet all interface and mounting requirements.

The advantages and disadvantages of the F3 strategy are: [Ref. 9:p. 40]

Advantages

1. Increased competition can be expected since a variety of production and design methods may be applicable to the requirement.

2. The F3 design/performance criteria encourages innovation and ingenuity in meeting the need. Since contractors are not unduly constrained by Government designs and production requirements new approaches to old problems arise utilizing ingenious new production or system technology delivering a superior product.

3. This strategy can be implemented without procurement of costly technical data, and the Government is relieved of the "Implied Warranty Doctrine" where the Government may be held liable for a contractor's nonperformance due to defective specifications.

4. The Government may be relieved of maintaining a technical data package which increases the trouble and cost of a system.

5. No transfer of technology or data is required between contractors which generally means a faster delivery of the system.

Disadvantages

1. The primary limitation of the F3 strategy is the logistical/maintenance philosophy associated with the system. Each item has a designated maintenance level at which repair is authorized. This system may produce items that are not suited for repair at lower echelons and would greatly increase the cost of maintaining spare parts inventories and training repair personnel.

2. The Government must pay for a second design effort.

2. Technical Data Package (TDP)

The TDP is a technical description of an end item and may contain technical drawings, plans, specifications, industrial standards, performance requirements, parts and associated lists, quality assurance and packaging data for the item. [Refs. 4: 10-4, 14:p. 34]

In this second sourcing method a contractor is contracted to build an identical end item from a Government provided TDP. Technology transfer is achieved strictly on the basis of the TDP with no contractor-to-contractor exchange. This means that the TDP is the one critical document in the procurement process. Since so much depends on the TDP package, plans must be incorporated early in the acquisition cycle to develop and test the package.

TDP´s are maintained in three levels. The first two levels, Level I and Level II, contain those engineering drawings developed during the CE, D&V, and FSD Phases. These levels are appropriate for manufacturing production prototypes for field testing and logistical support research. A difficulty with these drawings are that they usually

contain contractor unique legends which may refer to proprietary data or processes unknown to the second source. [Ref. 14:p. 36]

The Level III TDP is that document which by definition: [Ref. 14:p. 37]

> Allows a competent manufacturer to produce and maintain quality control of an item interchangeable with those of the original design without resorting to additional production design effort, data, or recourse to the original design activity.

The Level III TDP is contracted for as a deliverable item in the contract and must be planned for and validated prior to use. Failure to validate the TDP may lead to subsequent claims by the second source alleging defective specifications should he encounter problems during manufacturing. TDP validation is the process where the Government solely, or through a joint Industry-Government team, ensures that the package is accurate, current, complete and clear. This process is lengthy and complicated and will most likely require support outside of the program manager's office. The process entails methodical culling of the data to ensure that only relevant data are present, obsolete data are removed or updated, and that all engineering changes are present. Once validated, the TDP can be sent to the second source for manufacturing to begin. [Ref. 4:p. 10-9]

In providing the TDP, the Government assumes responsibility for appropriateness and completeness. History has shown that despite the best efforts of all concerned, the

majority of TDP´s are insufficient in one area or another. This is primarily because the simple transfer of engineering drawings does not impart the same level of expertise, knowledge or familiarity as does actual development and manufacturing experience. This "know-how" is an intangible which cannot be put down on paper and is the factor most troublesome in implementing the technology transfer. The General Accounting Office reported the following: [Ref. 15:p. 21]

> For manufacturing some advanced hardware, there can never be enough data, it seems, to achieve effective transfer of the technology. The critical factors may be craftsman´s skills, ingenious processes, "tricks of the trades", and esoteric shop practices which cannot be reduced to formal, indeed informal paper.

To overcome this difficulty, the Government may decide to transition a second source to full production by utilizing an "Educational Buy". The purpose of this procedure is to certify the ability and quality of the second source´s manufacturing system, and simultaneously gauge the accuracy and completeness of the TDP. This is accomplished by contracting with the second source to produce a limited, but sufficient number of items to substantiate the TDP along with the manufacturer´s ability to perform the required work. Once all problems are corrected the second source is qualified and competes against the original source for future production contracts. [Ref. 11:p. 50]

The advantages and disadvantages of the TDP strategy are: [Refs. 4:p. 2-6, 9:pp. 44-45, 16:p. 35]

Advantages

1. Provides for the most flexible competition by allowing for multiple sources, and for spares procurement in the out years of the contract.

2. Allows for maximum Government configuration control.

3. In-house Government technical expertise is developed during validation.

4. Fully supports the maintenance philosophy of the program by fielding only one variant of system.

5. Most flexible method of competition.

Disadvantages

1. Requires moderate to significant Government facilities and manpower to effect validation.

2. Production competition is not usually achievable until the third year of production when a baseline system has been established.

3. Government accepts responsibility for defects in the TDP.

3. Leader-Follower (LF)

The Leader-Follower (LF) strategy is defined in FAR 17.401 as:

> Leader company procurement is an extraordinary procurement technique under which the developer or sole source producer of an item or system (the leader company) furnishes manufacturing assistance and know-how or otherwise enables a follower company to become a source of supply for the item or system.

LF is used when the design or complexity of a system is such that a second source would be unable to manufacture the system without the aid and benefit of the original developer [Ref. 4: 11-1]. The most crucial issue with the L/F strategy as with the TDP strategy is the determination of technical data rights. This strategy parallels the TDP strategy in all

regards, except that the complexity of the system is such to require the manufacturing "know-how" of the developer to teach the second source the production process. If it is determined that proprietary data are involved with the process it may prove difficult for the Government to gain the developer's cooperation. Past practice has shown that the developer will price this data at a rate equal to the expected loss of business at the time of introduction of a second source. If the data has commercial applications the developer may be unwilling to divulge the data at any price. [Ref. 2:p. 36]

If it is determined practical to implement a LF strategy, the Government has three options to pursue by awarding a contract to the: (FAR 17.402(a))

1. Leader company, obligating it to subcontract a designated portion of the required end items to a specified follower company and to assist it to produce the required end items.

2. Leader company, for the required assistance to a follower company, and a prime contract to the follower for production of the end items.

3. Follower company, obligating it to subcontract with a designated leader for the required assistance.

FAR Part 17 also requires the Government to maintain the right to approve the follower source. Though several methods of follower selection exist and are designed to maximize particular production requirements, this right primarily protects the Government from having the leader choose a source either totally incapable of performance or

one that would require excessive effort to develop fully. [Ref. 9:p. 43]

The advantages and disadvantages of the LF strategy are: [Ref. 16:p. 34]

Advantages

1. Minimizes redundant hardware/software/firmware design developments.

2. Potentially overcomes data/data rights issues with Leader.

3. Utilizes unique Leader capabilities.

4. Allows Government contractual alternatives in dealing with the Leader/Follower.

5. Minimizes the Government's burden associated with technology transfer.

Disadvantages

1. If proprietary/patented data and techniques are involved, strategy resembles Directed Licensing.

2. The cost of motivating or incentivizing the Leader to participate.

3. Potential for complex contractual relationships between parties; Government may have to mediate conflicts.

4. Production competition usually not attainable until the third year of production.

5. Complex environment to maintain Government configuration contol.

4. Directed Licensing (DL)

The Directed Licensing (DL) strategy is a method closely related to the Leader-Follower strategy. The major distinction between the strategies is that the leader company has possession and rights to proprietary data and the follower pays a royalty fee for permission to use the patents

or processes owned by the leader. DL in its purest form seeks to solve both the issue of technology transfer and data rights simultaneously. This is accomplished by the Government paying for the right to use technical data and through the face-to-face contractor exchange of information and manufacturing "know-how". This added expense though will raise the cost of the system and should only be used when the Government is unable to procure unlimited data rights, in which case the TDP or L/F strategy is utilized. Since DL rarely, if ever, reduces program costs it is used primarily as a method of establishing a production/mobilization base or in pursuing second sourcing goals other than cost reduction. [Ref. 17:p. 4]

The advantages and disadvantages of the DL strategy are: [Ref. 9:pp. 47-48]

Advantages

1. The potential for production competition is maintained throughout the acquisition cycle.

2. The Government need not become closely involved with the actual transfer of technology between sources.

3. Quantity production decisions and source of supply decisions can be postponed until later in the acquisition process.

4. The designer is provided with protection as to how, or in what markets, the second source is to be licensed to sell the product; and, the designer may be compensated for each item produced by the second source.

5. The Government is saved the expense of paying for a second design effort.

Disadvantages

1. The existence of royalty and technical assistance fees increase the cost of the acquisition and could be prohibitive.

2. It may be difficult to achieve the necessary degree of cooperation between alternative production sources, and the licensee may have little recourse against half-hearted cooperation on the part of the licensor.

3. Some contractors may bid on projects simply to obtain proprietary information on other producers´ designs.

4. It may become difficult to maintain accountability.

5. Contractor Teaming (CT)

Contractor Teaming is a strategy where two or more companies with similar research, development, and production capabilities join together to form a contract team. The teaming can be accomplished during either the CE or D&V phases, but must be done at the very latest upon entering the FSD phase. Once formed, the team competes in the development of the system against other contractors or contractor teams sharing all technical data that is gained from their co-development effort [Ref. 18:p. 31]. Since both contractors transfer technology through the development effort, both contractors are qualified concurrently. At the completion of the FSD the contract team may be split and will compete against each other for production contracts.

A CT arrangement can be implemented contractually in two ways: [Ref. 4:p. 13-2]

1. A prime contract awarded to one of the team members would specify the requirement to award a subcontract to a team member.

2. The team members could form a separate, joint venture, to which the Government would award a prime contract.

When considering soliciting for the formation of a contract team several factors must be considered in judging this methods applicability: [Ref. 18:p. 34]

1. The existence of a sufficient number of capable contractors in the industrial base, each with similar capabilities.

2. Contractor motivation to enter into contractor teaming arrangements.

3. Identification and implementation of a CT strategy into the program acquisition strategy early on in the acquisition cycle.

The advantages and disadvantages with the CT strategy are: [Refs. 9:p. 51, 11:p. 72, 16:p. 33, 18:p. 36, 19:pp. 37-38]

Advantages

1. Second sources are developed as part of the development process. This eliminates the problem of qualifying a second source since both contractors were involved with the design and possibly initial production/prototype efforts.

2. Technical success is enhanced by the efforts of two contractors forming a design team.

3. Government liability for technical data is limited.

4. Competitive production is achieved much earlier than under other methods of dual sourcing, possibly with the first production lot, lowering unit production costs due to maintenance of competition in the production phase of the acquisition.

5. Cost free sharing of technology between the co-developers.

6. Built-in price competition during the life of the design competition with the possibility of production competition.

7. High level of fleet/combat readiness through higher initial and prolonged production rates from proven sources.

Disadvantages

1. Possibly lengthening the source selection process.

2. Increasing source selection costs since two contractors are involved with each proposal.

3. Increases configuration control efforts by the Government once production has begun.

4. Original partitioning of responsibilities must be overcome if independent competition is to occur quickly.

5. As the splitting of the team approaches, the Government may find difficulty in ensuring full and open transfer of technology between the team members.

6. May prove difficult to maintain production competition if team becomes significantly unbalanced in financial resources/health, facilities or technical capability.

Now that the reader has a knowledge of the CT strategy, the question might arise as to what would motivate normally adversarial contractors to be willing to form joint development teams. One reason appears to be the reduction in research and development costs borne by each member. Also the complexity of modern weapon systems may mandate that without the knowledge of two or more leading developers in the field, the system would not be completed or would require excessive time and effort. Such is the case with the Air Force's ATF (Advanced Tactical Fighter) and the Joint Service V-22 "Osprey" (Tilt Rotor Aircraft). If mandated by the Government as a requirement to compete for the contract, a firm may find that this program will probably be the "only

game in town" [Ref. 18:p. 53]. The Air Force will not develop a new fighter for the 21st. century on a regular basis, nor will the opportunity to learn from the development effort be available either. Failure of the contractor to participate in the competition in accordance with the Government's requirements may preclude the contractor from competition in the DOD market for a particular system for many years. Such a resulting loss may prove catastrophic to a defense contractor. In the case of CT, the Government is taking full advantage of its position as a monopsony to model a market place that fits its desire for an effective competitive market.

D. THE SECOND SOURCE METHOD SELECTION MODEL

In evaluating the five dual sourcing methodologies previously presented, the use of the Second Source Method Selection Model (SSMSM) provides the program manager a practical tool with which to judge the attractiveness of each method. The model divides program variables into three categories: economic, technical, and program management. Each program variable is then evaluated on a five point system to rank the effectiveness/suitability of the proposed method. [Ref. 4:p. 3-7]

- * for a particularly preferred method
- \+ for strong effectiveness
- 0 for neutral effect

- \- for weak effectiveness
- x for a particularly inappropriate method

It is important to understand that variable ratings are not additive. Any single overriding negative rating on a variable could cancel the effectiveness of a particular method, while an overriding positive factor could be justification to pursue a particular method. The model´s value is not that it is a deterministic model, but rather that it presents program variables in an orderly and logical manner in which the program manager can conduct a comparison of the influence that each variable may have as it relates to the second sourcing decision. Table II presents the SSMSM. [Ref 4:p. 3-8]

E. SUMMARY

This chapter presented the five second sourcing methodologies used to develop and introduce competition into the production phase of the acquisition process. It also presented the Second Sourcing Method Selection Model (SSMSM) as a means of evaluating the relative merits of each second sourcing method. This evaluation is based on an analysis of the unique economic, technical, and management variables of a program. The SSMSM provides a convenient and ordered technique of determining which second sourcing methods should be analyzed further for possible use by the program.

TABLE II

SECOND SOURCE METHOD SELECTION MODEL

Decision Variable	Form Fit Function	Technical Data Package	Licensing	Leader Follower	Contractor Teaming
<u>ECONOMIC</u>					
Quantity					
High	+	+	+	+	+
Medium	+	+	0	0	+
Low	0	0	-	-	0
Duration					
Long	+	+	+	+	+
Medium	+	+	0	+	+
Short	0	0	x	x	0
Tooling Cost					
High	-	-	-	-	x
Low	+	+	+	+	+
Progress Curve					
Steep	-	-	-	0	0
Flat	+	+	+	+	+
Contractor Capacity					
Excess	-	-	-	-	-
Deficient	+	+	+	+	+
<u>TECHNICAL</u>					
Complexity					
High	0	x	+	+	*
Medium	+	-	+	+	+
Low	+	+	+	+	+
State-of-the-art					
Pushing	0	x	+	+	*
Within	+	+	+	+	+
Other Applications					
Yes	+	0	+	0	+
No	+	+	+	+	+
Private R&D					
High	0	x	0	x	-
Low	+	0	+	+	+
<u>PROGRAM</u>					
Maintenance Requirements					
Complex	x	0	0	0	0
Nominal	+	+	+	+	+
Production Lead Times					
Long	-	-	-	-	-
Short	+	+	+	+	+
Degree of Subcontracting					
Heavy	0	-	-	-	-
Light	+	+	+	+	+
Contract Complexity					
Complex	-	-	-	-	-
Simple	+	+	+	+	+

Source: <u>Establishing Competitive Production Sources</u>, 1984.

IV. COMPETITION IN AUTOMOTIVE COMMODITIES

A. GENERAL

Table I, Chapter II, presented evidence that substantiated the often heard claim that the introduction of competition into weapon systems procurement could reduce the costs of these systems. However, Table I presented data for only three commodities: Electronics, Missile/Components, and Small Support Equipment. None of these categories match the characteristics of the Automotive commodity in which the Advanced Assault Amphibian Vehicle (AAAV) would be included. The question posed then is: "Will competition in Automotive commodities deliver the same effect of reducing costs as had been observed in other commodities"? A review of the procurement history of Automotive commodities since 1959 indicates that the answer to this question is "yes", and that three conclusions have been formulated: [Ref. 20:p. 5]

1. Automotive commodities have unique characteristics.
2. Competition can generate savings even when the incumbent producer never looses.
3. Post award claims and adjustments may be a significant risk of competition.

Table III presents a summary of the available historical data showing the effects of competition on the contract pricing of armor vehicles, which are contained within the Automotive commodity [Ref. 20:p. 7]. The Table shows that

TABLE III.

PROGRESS CURVES EXHIBITED IN THE ARMOR VEHICLE DATABASE

Vehicle	Curve Slope S/Source	Curve Slope Competitive	Contract-to-Contract Competitive	Contract-to-Contract S/Source
M113	100%	91%		(7.0%)
M548	100%			(9.0%)
M577	100%		12%	(11.0%)
M125	100%		16%	(15.0%)
M106	100%		14%	(41.0%)
M60			31%	(10.0%)
M60A1	100%			(5.0%)
M88		98%		.6%
M109A1B	95%			(3.0%)
M109A2	100%			(1.0%)
M110	100%			(5.0%)
M578	100%			(6.0%)
M320RT		93%		(55.0%)
AAV7		97%		

Source: Competition in Automotive Commodities: Implications for Competitve and Non-Competitive Acquisition Strategies, 1982

when competition was present during the acquisition process, savings resulted from unit price reductions due to the effect of the learning curve. When competition was not present and a sole source procurement was made, either negative or no learning was demonstrated and unit prices exhibited a pattern of price escalation. Appendix B presents the acquisition price history of each vehicle and graphs the exhibited pricing pattern between competitive and sole source awards [Ref. 20:Appendix D].

B. VEHICLE FAMILY

1. M113 Family

The M113 is the base vehicle chassis for a family of vehicles which includes the M113 Armor Personnel Carrier (APC), M577 Command Post, M548 Cargo Carrier, M125 Mortar Vehicle, and M106 Mortar Vehicle. FMC Corporation continuously produced the vehicle from 1959 to 1982, the years which the Watkin´s study [Ref. 20] researched, with derivative vehicles introduced at several points in the production timeframe.

a. M113 Armor Personnel Carrier (APC)

The base vehicle, the M113, was introduced in 1959, in 1964 the M113A1 configuration was introduced with several hundred minor changes but with no significant impact on program cost, and in 1979 the M113A2 configuration was introduced with significant design changes to the vehicle. Due to these changes the M113A2 was excluded from the research. [Ref. 20:p. 5]

The M113 APC was competed almost every year between 1959-1971 on a winner-take-all award basis. In addition, two multiyear contracts were awarded in 1965 and 1969. These production contracts resulted in over 38,000 vehicles being produced. Through this phase of the acquisition the production demonstrated a price progression commensurate with a 91% learning curve. [Ref. 20:p. 6]

The competitive price behavior contrasts sharply with the sole source award period between 1971-1978. The acquisition price for these awards is distinguished by constant dollar increase of approximately 7%. The very first sole source award resulted in an increase of 16% over the previous competitive award without any indication that the increase was warranted by design changes. [Ref. 20:p. 8]

b. M548 Cargo Carrier

The M548 was competitively awarded only for the first year´s production. Subsequent awards were sole source and demonstrated a pattern of 9% annual price increases. [Ref. 20:p. 8]

c. M577 Command Post

The M577 was competitively awarded three times, initially on the first production award, and later on two non-consecutive awards. Prices for competitive awards demonstrated 14% and 20% reductions in constant dollars, while sole source awards averaged 11% increases excluding a 1969 award which tripled the quantity of vehicles. If this award is taken into consideration the average cost growth is 7%. [Ref. 20:p. 8]

d. M125 Mortar Vehicle

The M125 was competed only once after initial production. This competitive award demonstrated a 16% price reduction in constant dollars, sole source awards averaged 15% price increases. [Ref 20:p. 8]

e. M106 Mortar Vehicle

A total of seven production contracts were awarded for this vehicle: two competitive, four sole source, and the initial competitive award. Competitive awards demonstrated price savings of 18% and 10%, while sole source awards resulted in a 41% increase in constant dollars over the initial contract price. [Ref. 20:p. 9]

f. Summary of M113 Family

Analysis of the M113 family clearly demonstrates that for a period of 20 years competition exerted influence on the price paid, in constant dollars, for the vehicle. The most striking support for this conclusion rests with the fact that for 12 years FMC had produced the M113 APC with a demonstrated 91% progress curve, and that the price of the vehicle in constant dollars dropped accordingly over the period. After competitive awards ceased, the first sole source award resulted in a 16% price increase. Similar observations of price behavior when confronted with competition, or the lack of such competition, are observed in other vehicle variants and support the conclusion that competition does favorably impact on the price paid for automotive commodities. [Ref. 20:p. 5]

2. M60 Main Battle Tank (MBT) Family

The M60 MBT was produced by Chrysler Corporation in four configurations: M60, M60A1, M60A2, and M60A3 [Ref. 20:p. 10]. Pricing data for production contracts for all

configurations are incomplete in available research material; however, available data for the M60 and M60A1 configurations indicate that MBT class vehicles exhibit competitive pricing characteristics similar to other commodities.

a. **M60 MBT**

The M60 MBT was produced between 1959-1963, information is only available for the first two years procurement. The initial production contract for the M60 was awarded in 1959 on a sole source emergency basis while a competitive solicitation was prepared. The following year, a final award was made to two contractors which resulted in a 31% reduction from the previous award. [Ref. 20:p. 10]

b. **M60A1 MBT**

The M60A1 was produced in non-consecutive sole source production runs during 1962-1966, 1968-1972, and 1974-1979. The period 1964-1976 demonstrated a pattern of rising prices in constant 1980 dollars which amounted to a 49% increase in per unit price. This pattern was exhibited even though the vehicle configuration was relatively stable. The years 1977-1979 were excluded from the study because several expensive upgrades to the vehicle and the component breakout of the track made comparison of prices impractical. [Ref 20:p. 11]

c. **Summary MBT**

MBT figures support the theory that competitive pressure can achieve reductions in production price for

automotive commodities. However, their relevance might be questioned due to the confusion that existed in the program and the breaks in production experienced. The acquisition program for MBT's was in a state of turmoil from approximately 1967-1976. It was during this timeframe that the Army was involved with the unsuccessful development of the M-70/XM-803 MBT. This MBT was supposed to be the designated successor to the M60 family. The XM-803 program was cancelled in December 1971 after a lengthy dispute with Congress and was followed immediately by the controversial XM-1 "Abrams" tank program. The transition of the XM-1 to FSD on 12 November 1976 brought a measure of stability and certainty to MBT production. The atmosphere of uncertainty regarding the potential for future production of M-60 MBT's, in concert with the broken production phase contracts, complicates drawing conclusions from MBT figures. However, the exhibited price behavior does, on face value, support the hypothesis that competition does affect the price of automotive commodities. [Ref. 21:p. B-6]

3. Assault Amphibian Vehicle (AAV) Family

The AAV7 family of vehicles consists of three variants which include a Personnel, Communication, and Retriever models. These vehicles were all produced under a four year multiyear, firm fixed price contract, between 1970-1973, with a total of 946 vehicles produced. The negotiated contract price for the production demonstrated that the

manufacturer, FMC Coproration, agreed to a 97% progress curve during production. FMC was awarded the contract after determination that its bid was the lowest priced of four competiting offers. [Ref. 22:pp. 51-54]

C. SUMMARY

Chapter IV presented historical data reflecting the awarded contract pricing exhibited by the Automotive commodities, of which the AAAV is a member. The evidence presented supports the hypothesis that the existence of competition in the acquisition process can reduce the cost of procuring a weapon system, and that in the absence of competition the tendency is for the price of the system to rise. The evidence also demonstrates that the progress curve for Automotive commodities are generally shallow, and that the most favorable curve exhibited to date is 91% for the M113 APC vehicle. [Ref. 20:p. 5]

V. ADVANCED ASSAULT AMPHIBIAN VEHICLE PROGRAM

A. GENERAL

The Advanced Assault Amphibian Vehicle (AAAV) is the U.S. Marine Corps proposed answer to an identified mission need for an over the horizon, surface assault capability, which is capable of executing forced entry/assault operations. The AAAV will be the next generation of Assault Amphibian Vehicle (AAV) and will replace the AAV7A1 vehicle which was introduced in 1982. The AAV7A1 utilized existing technology, and incorporated it into the AAV7 family of vehicles through a Service Life Extension Program (SLEP).

B. CURRENT ACQUISITION STRATEGY

1. General

The AAAV has an Initial Operational Capability (IOC) requirement of FY-99. The IOC was the primary constraint considered when the program office formulated the acquisition strategy [Ref. 23:p. 2]. Figure 8 shows the current acquisition strategy milestone plan (all milestones begin in the first quarter of the given fiscal year).

2. Concept Exploration

The CE phase will occur over a 24 month period commencing with Milestone 0 which is scheduled to begin in approximately January 1989. The current acquisition strategy calls for the award of three fixed-priced competitive

Concept Exploration		Demonstration & Validation			Full Scale Development				Production
89	90	91	92	93	94	95	96	97	98 - 01
* 0									
		* 1							
					* 2				
									* 3

(* = Milestone)

Figure 8. AAAV Acquisition Strategy

Source: Developed by the Researcher.

design/study contracts to address such characteristics as performance, supportability, producibility, cost, schedule, and risk. The CE contract will also contain an option for the conduct of the D&V Phase effort. [Ref. 23:p. 5]

3. Demonstration and Validation

The D&V Phase will be exercised by two of the three CE contractors. Award of these contracts will be based on the contractor´s concept design studies performed during CE and the cost and technical proposals for the D&V effort. [Ref. 23:p. 6]

The D&V Phase will require each contractor to design and fabricate two AAAV personnel prototypes. In addition, each contractor will be required to design and fabricate a presently undetermined Mission Role Variant (MRV) prototype. [Ref. 23:p. 6]

Demonstration Test/Operational Test (DT/OT-1) is scheduled over a six month period commencing in the second quarter of FY-93. The DT/OT-1 event will constitute a run-off between competitive designs and together with technical and cost proposals for FSD will serve as the basis for transitioning the Milestone II Defense Acquisition Board (DAB) review. In addition the program office will include in the FSD solicitation a requirement for the predetermination and pricing of proprietary rights to data and require each contractor to develop a plan for assisting the Government in establishing a second production source. [Ref. 23:p. 6]

4. Full Scale Development

The present AAAV acquisition strategy calls for one contractor to be carried forward into FSD. However, the program office is considering: [Ref. 23:p. 7]

> A teaming arrangement whereby a contract is awarded to a firm other than the prime contractor to maintain an engineering team that analyzes and participates in the development of the FSD prime contractor's technical data.

The FSD contract will require the contractor to continue to refine the AAAV design and to fabricate 15 prototype vehicles for a DT/OT-II effort commencing the third quarter FY-95. DT-II will be conducted over a 30 month period, with OT-II being conducted by Fleet Marine Force units over a three month period early in FY-97. These efforts will serve as a basis for transitioning the Milestone III decision in late FY-98. [Ref. 23:p. 7]

A Level III TDP will be required as a deliverable item under the FSD contract.

5. Production

In order to meet the IOC requirement of FY-99, award of the production contract (Milestone III) will be conducted in late FY-98. It is anticipated that a single production contract will be competitively awarded on a fixed-price type contract utilizing the Level III TDP for a competitive solicitation. Alternate strategies, which will be evaluated as program uncertainties are resolved, include either a competitive solicitation of a second source utilizing the Government's Level III TDP, or the use of a Leader-Follower option in the production contract which requires the prime to develop a second source for the Government. [Ref. 23:p. 8]

The production will require the delivery of approximately 1500 AAAV's with the production phase encompassing a 40-60 month period.

C. ANALYSIS OF CURRENT AAAV ACQUISITION STRATEGY

1. Design Competition

Analysis of the current AAAV acquisition strategy indicates that the program office, in accordance with SECNAVINST. 4210.6A, is planning for design competition in both the CE and D&V phases of acquisition. This competition, as previously discussed, calls for the award of three contracts entering CE, followed by a down selection to two contractors entering D&V. In addition, as encouraged by

DODI. 5000.2, the program office is requiring the prototyping of two or more vehicles per contractor as a requirement during the D&V phase. The prototyping effort will assist in defining engineering and technical risk factors in the program and provide for a "Shoot-off/Roll-off" between the competing designs. The design effort during CE and D&V fully supports, within the limitations of the program budget, DOD policy regarding maintaining design competition during early phases of the acquisition cycle.

The acquisition strategy, however, currently calls for a down selection to one contractor entering into a four year FSD phase which will end design competition. In the view of the program office, the primary limiting factor that mandates this decision is the nonavailability of funds to permit two separate contractors to manufacture 15 prototype vehicles each during FSD [Ref. 23: Appendix G]. Current budgetary planning for prototype vehicles procured during FSD establishes a ceiling of $12.5 million per vehicle [Ref. 24:p. 13]. The maintenance of design competition into FSD would require at a minimum an additional $187.5 million for an additional 15 prototypes, plus additional management costs to support the broadened program. Prototype vehicles are scheduled for use in DT/OT-II testing during FSD with the test results serving as the basis for the Milestone IIIA decision.

Splitting the budgeted prototype quantity between the two contractors is not considered advantageous to the design effort because of the tactical configuration of the AAV platoon. This configuration consists of ten personnel (P) vehicles per platoon, for which ten prototypes are dedicated, with the five additional prototypes dedicated to vehicle variants (Communications, Retriever etc.) and the accompanying "chase" (P) vehicles. It is generally agreed that the best results and analysis from DT/OT-II testing will be derived from exercises that evaluate the vehicles in their approved tactical and organizational units. Thus splitting the prototype quantity would result in the side by side testing of different designs, in quantities insufficient to correctly evaluate their performance abilities or maintenance requirements. [Ref. 25]

The down selection to one contractor entering FSD may also encourage the introduction of a "buy-in" strategy by the contractors. As previously discussed, the contractors will face essentially a "winner-take-all" award entering FSD with the view that whomever wins the development contract will inevitably win the production contract. The likely occurrence of a "buy-in" at a time when the technology remains unproven, the design baseline is not final, and issues involving producability are not resolved, sets a stage that is conducive to potential cost escalation. Even if production options could be utilized entering the FSD phase

in an attempt to control costs and smooth the transition to the production phase, it can be expected that the contractor will either adjust the price of the option upwards to reflect the degree of risk that exists, or later disown the estimates.

The use of production options as a selection criteria for award of the FSD contract was employed in the M-1 MBT program as part of an intensive Design to Cost (DTC) effort [Ref. 21:p. E-4]. The financial transition from FSD into production was to be smoothed by exercising the production options signed during competition for the FSD contract. The options established a ceiling price in accordance with DTC goals for the first two years of production. Three years later, however, when the Government exercised the options at a Milestone IIIA decision for low rate initial production, the ceiling price proved to be too low. The contractor subsequently tried every method at its disposal to increase the price including generating claims against the ceiling price for equitable adjustments with the result that substantial increases were made to the ceiling price [Ref. 21:p. G-6]. The program office stated: [Ref. 21:p. E-13]

> In spite of all the good work done during the process, one must realize there is no commitment on the part of the contractor to finally sell the product at the predicted price. Once the production decision is made, the "sales job" conducted during FSD is over, and the contractor will disown his own predictions and charge the Government whatever the market will bear.

In addition, the ever present attitude of "getting well on engineering changes" that history has shown occurs frequently, presents ample opportunity for a sole source to recover financially from any commitments that were made in the effort to acquire the contract. The AAV7 program implemented 450 ECP´s on the production of the AAV7 and over 2000 on the AAV7A1. [Refs. 22:p. 52, 26]

Though the program is considering a strategy of awarding a contract to a firm other than the prime to maintain an engineering team that analyzes and participates in the development of the prime´s technical data, this strategy does not enhance or continue design competition. This effort as envisioned will primarily support the validation of the Level III TDP which is scheduled to be delivered to the Government at the end of FSD, and enhances the probability of achieving production competition based on the TDP.

2. Production Competition

a. General

The current strategy for attaining production competition begins with the RFP for the FSD phase. In the RFP the program office will state that: [Ref. 23:p. 8]

> One of the evaluation criterion for award of the FSD contract will be the offer´s plan for helping the Government establish a second source for production vehicles.

The requirement for the contractor to develop a second sourcing plan for the Government´s review puts the

contractor on notice that production competition is a stated objective of the program during the production phase. In addition, the RFP will require a predetermination of data rights and the elimination of proprietary data and contracts for the delivery of a Level III TDP.

b. TDP Strategy

It is on the Level III TDP, with the resultant TDP Strategy, that the production competition strategy currently rests.

Current production plans call for the competitive award of a single contract to a sole source based on a competitive solicitation utilizing the Level III TDP. If design, production, and cost variables warrant, consideration will be given to soliciting for a second production source again utilizing the TDP, or the use of a Leader-Follower Strategy should the technical complexity of the system require.

Experience with the TDP strategy has demonstrated that it is the most hazardous of the dual sourcing strategies, and is not well-suited for state-of-the-art systems with unstable designs, unproven technical aspects, and new production processes [Ref. 27:p. 14]. In addition to the critical factors of craftman know-how and shop procedures which cannot be definitized and recorded in the TDP, practice has revealed that quite often the TDP has major deficiencies in either accuracy, adequacy, currency, completeness or

clarity [Ref. 14:pp. 47-48]. Once the data package is accepted by the Government and is used as the basis for a solicitation, the Government effectively guarantees the adequacy of the package and assumes any resultant liability should deficiencies appear. With the risk involved in the use of the TDP strategy it is questionable whether, on a production phase of only four to five years, this strategy will deliver true competitive pressure on cost. This strategy also adds the question of what action the program office will take should another contractor underbid the original FSD developer. A second contractor would be well aware of past difficulties of production utilizing a TDP and will be well aware of its legal options under situations of defective specifications within the package. This could result in a buy-in to the production contract knowing well that there may be little possibility that it will actually be called upon to perform as expected.

c. **Leader-Follower**

The current acquisition strategy recognizes the possibility of introduction of a LF strategy either during FSD or once into production. Introducing this strategy during FSD equates with the program office's desire to form what is termed a "teaming arrangement" in the acquisition strategy, and calls for the follower to "maintain an engineering team that analyzes and participates in the development of the FSD prime contractor's technical data

package" [Ref. 23:p. 7]. This strategy has the advantage of requiring potential leaders to submit LF plans as a source selection criterion for the FSD contract award while competitive pressures still exist. This use of this option increases the probability of an effective technology transfer. The program office will evaluate this option as program variables develop to a reliable level.

3. Prototyping

The extent of the prototyping effort by the program office warrants special discussion because it is, at this moment, the prime cost reducing technique being utilized in the acquisition strategy. It also provides for a more concrete comparison of design concepts during design competition than would be possible using only paper concepts and diagrams.

The increased use of prototype systems was encouraged by the "President´s Blue Ribbon Commission On Defense Management", better known as the Packard Commission, which recommended: [Ref. 28:p. 55]

> A high priority on building and testing prototype systems to demonstrate that new technology can substantially improve military capability, and to provide a basis for realistic cost estimates prior to a full-scale development decision. Operational testing should begin early in advanced development, using prototype hardware.

Research evidence comparing 17 mature programs, with four of these programs utilizing prototyping efforts (A-10, F-16, AH-23, and UH-60), indicates those programs that

utilized prototyping experienced lower than average cost growth. This occurred because prototyping appeared to enhance and reaffirm the accuracy of previous cost estimates, and provided contractors a better appreciation of system interfaces and for possible production difficulties that could be encountered. Also prototyping appears to increase system quality by providing earlier and more detailed identification of potential problems during DT/OT testing. Flight tests of both the A-10 and F-16 aircraft indicated several problems ranging from simple pilot dissatisfaction with the cockpit layout of the A-10 to autostabilization problems with the F-16. Identification of potential problems during FSD provides an opportunity to correct these problems before they appear on production models that could require expensive corrective action. [Ref. 29:p. 35]

D. SUMMARY

Chapter V presented the acquisition strategy as currently proposed in "Plan for Assault Amphibian Vehicles" [Ref. 23]. The strategy as stands emphasizes design competition, in conjunction with an aggressive prototyping effort, during the CE and D&V phases. The strategy acknowledges the possibility or potential for production competition, and envisions the use of either a TDP or LF method should program variables indicate that the benefits from such an effort would be advantageous to the Government. In Chapter VI an analysis

will be presented which evaluates the merits of introducing production competition through a second sourcing effort.

VI. DUAL SOURCING ANALYSIS

A. ANALYSIS OF PROGRAM VARIABLES UTILIZING THE SECOND SOURCE METHOD SELECTION MODEL

Preliminary analysis of the AAAV program for suitability in using a second sourcing competitive strategy will be accomplished employing the SSMSM. Table IV presents the ratings of the variables and provides a side-by-side comparison between methodologies.

1. Economic Variables

a. Quantity

The anticipated AAAV requirements of the Marine Corps are approximately 1500 vehicles of all types. This includes a proposed production requirement for the AAAV "Personnel" variant of approximately 1375 vehicles [Ref. 30:p. 1-5]. This figure also allows for approximately 125 total vehicle variants for the Marine Corps, i.e., Communication and Retriever vehicles. Current estimates for foreign military sales expect that a maximum of 500 vehicles will be ordered [Ref. 25]. Totalling the needs of both the Marine Corps and foreign sales results in a total of between 1600-2000 vehicles ultimately produced.

This quantity is low by commodity standards when compared to the procurement of 54,959 M113/M113A1 vehicles, or over 8,800 M60/M60A1 MBT´s. Present production plans for

TABLE IV

SECOND SOURCE METHOD SELECTION MODEL

Decision Variable	Form Fit Function	Technical Data Package	Directed Licensing	Leader Follower	Contractor Teaming
ECONOMIC					
Quantity					
Low	0	0	-	-	0
Duration					
Short	0	0	x	x	0
Tooling Cost					
Low	+	+	+	+	+
Progress Curve					
Flat	+	+	+	+	+
Contractor Capacity					
Deficient	+	+	+	+	+
TECHNICAL					
Complexity					
High	0	x	+	+	*
State-of-the-art					
Pushing	0	x	+	+	*
Other Applications					
No	+	+	+	+	+
Private R&D					
Low	+	0	+	+	+
PROGRAM					
Maintenance Requirements					
Complex	x	0	0	0	0
Production Lead Times					
Short	+	+	+	+	+
Degree of Subcontracting					
Heavy	0	-	-	-	-
Contract Complexity					
Simple	+	+	+	+	+

Source: Developed by the Researcher.

Legend

(*) - Particulary Preferred (-) - Weak Effectiveness
(+) - Strong Effectiveness (x) - Particularly Inappropriate
(0) - Neutral

the M-1 "Abrams" MBT are in excess of 7,300 vehicles and over 7,200 of the M-2 Bradley Fighting Vehicle (BFV).

Though the AAAV quantity is low by commodity standards it still represents an increase in AAV assets for the Marine Corps of between 4-12%. In addition, when compared with the results of the AAV7 production in which 946 vehicles were manufactured by a sole source at a rate of 30-35 per month, and if an optimistic outlook of 400-500 AAAV´s for foreign military sales is considered, it is conceivable that two production sources could effectively compete for a split production of nearly 2,000 vehicles. This variable is rated "LOW" based on comparison with historical Automotive commodity production data for vehicles.

b. Production Duration

The duration of the production phase is anticipated to be between 40-60 months [Ref. 25]. This estimate was computed by dividing the minimum/maximum vehicle requirements by the anticipated production rate of 30-35 vehicles per month. This variable is equivalent to the four year production of the AAV7 family, but is considered a short duration when compared to the 29 years production experienced by the M113 family, the 10 years of the M60 MBT, and the current eight years of the M1 MBT and the M-2 BFV. This variable is rated as "SHORT" based on comparison with historical automotive commodity production data for vehicles.

c. Industrial Facilities

Historically the industrial facilities investment for the establishment of a production line capable of producing armor vehicles is substantial. The Life Cycle Cost Estimate (LCCE) for the AAAV anticipates industrial facilities of $238,253,000 in FY 88 dollars [Ref. 30:p. 1-12]. This amount was derived by determining the cost of facilities as a percentage of total recurring hardware cost for six other armor vehicle programs (M1, BFV, M110, M551, M113, and M114A1) at the 1000th unit and computing the mean of the values. This mean value (8.1%) was applied to the computed recurring hardware cost for the 1000th. unit of the hypothetical LCCE AAAV to arrive at the estimated facilities cost. [Ref. 30:p. 3-22]

The LCCE industrial facilities cost estimate methodology, however, may be considered flawed or pessimistic in the approach employed to determine the facilities cost. This is because the AAAV will more closely resemble in size and complexity the characteristics of the M113 and the BFV. These two vehicles are both in the armored personnel carrier/armored fighting vehicle family, and have characteristics different than those exhibited by MBT´s (M1) or self-propelled artillery vehicles (M110). The BFV and M113 have demonstrated industrial facilities costs, as a percent of recurring hardware costs at the 1000th unit, of 2.0 and 2.3 percent respectively. The other vehicles used in

the study, notably the M1 and the M110, have industrial facilitization costs of 13.0 and 13.7 percent respectively. These classes of vehicles are substantially heavier, carrying up to twice the weight of the AAAV, and mandate the added effort required to handle a large turret/weapon station which will not be present with the AAAV. [Ref. 30:p. 3-23]

If the facilities costs of the BFV and the M113 are averaged, a mean value of 2.15% results. Using an industrial facilities cost value in the area of 2.15% results in a cost of $68,989,200 for 1500 vehicles. This figure compares favorably with an estimate of $50 million for industrial facilities suggested by FMC Corporation when questioned about the required facilities to produce a hypothetical AAAV [Ref. 32]. This variable is rated "LOW" when compared to other armored vehicles.

d. Progress Curve

Progress curves for armor vehicles, as indicated in Chapter IV, are flat/shallow. The most favorable curve exhibited was for the M113 vehicle at 91% over a 12 year period during which approximately 38,000 vehicles were produced. A progress curve of 97% was negotiated for a four year multiyear contract with FMC Corporation for the production of the AAV7 family of vehicles in 1972 [Ref. 22:p. 52]. An interview with a program executive currently involved with the manufacture of the BFV indicates a progress curve of 88%-90% could be obtainable during production runs

at planned capacity [Ref. 31]. This variable is rated "FLAT".

e. Contractor Capacity

Contractor capacity at the time of production is unknown, but is assumed to be adequate for the effort required. Since no production facility is currently manufacturing AAV vehicles it should be possible to minimize the problems associated with excess contractor capacity. Knowing the program requirements for total production and production rate, and should a dual sourcing strategy be committed to, the program office could facilitize each developer for 60-70% of planned capacity or the minimum production facilities capable of manufacturing the AAAV. This variable is rated "DEFICIENT" based on the above scenario of tooling the developer for less than 100% of production rate.

2. Technical Variables

a. Complexity

The AAAV as currently envisioned will be a highly complex system employing subsystems not used in any other armor vehicle. These systems may include a developmental marine drive system capable of skimming a 62,000 lb. armor vehicle over the water at 25 knots, a retractable suspension system, a remotely operated weapon station, a developmental 2200 horsepower engine, and a composite material hull with

applique ballistic armor protection. The rating of this variable is rated "HIGH". [Ref. 25]

b. State-of-the-Art

The technology involved with the AAAV will be increasing the capabilities of amphibious assault well beyond those that exist in any other similar vehicle. If water speed performance specifications are met, a minimum 300% increase over the existing system is required. The variable is rated "PUSHING".

c. Other Applications

The AAAV is an amphibious armor vehicle unique to the U.S. Marine Corps and foreign military organizations with similar missions. Material and subsystems developed for this vehicle will have little or no probability for other use. This variable is rated "NO". [Refs. 25, 32]

d. Private Research and Development

The U.S. Marine Corps has continued to fund R&D efforts in the AAAV program, though at times under different program titles, since the early 1970's. It currently possesses all technical data rights for several major components of the system and according to the current acquisition strategy will acquire data rights to all components arising from further development. This variable is rated "LOW". [Refs. 25, 32]

3. Program Management Variables

a. Maintenance Requirements

The maintenance requirements for the AAAV necessitate the fielding of identical versions of the vehicle. The maintenance philosophy calls for the vehicle to have major repairs performed behind the forward edge of the battle area by AAAV maintenance personnel organic to the AAV battalion and company. It is impractical to train maintenance personnel to repair more than one version of the vehicle and for logistics organizations to supply and transport multiple uncommon replacement parts. This variable is rated "COMPLEX".

b. Production Lead Times

Past experience with AAV vehicles has demonstrated that there are few long lead time elements involved with production of the vehicle. However, since the AAAV is a new vehicle with no similar vehicle in existence there exists some likelihood that a major production component may fall within this category. This variable is rated "SHORT" based on historical precedence.

c. Degree of Subcontracting

The AAV7 was produced by FMC corporation almost in its entirety with a minimal amount of subcontracting. The degree of subcontracting increased; however, with the Service Life Extension Program (SLEP) of the AAV7 to the AAV7A1 but was still light. Discussions with FMC Corporation who have

considerable experience with the production of AAV's and who are currently the sole source for the BFV indicate that approximately 40% of the unit hardware cost should be subcontracted [Ref. 31]. Based on the above analysis this variable is rated "HEAVY".

d. Contract Complexity

The present acquisition strategy calls for the award of fixed-price type contracts for development and production of the vehicle [Ref. 23: Appendix H]. This variable is rated "SIMPLE" based on the acquisition strategy.

B. DUAL SOURCING METHODOLOGY ANALYSIS

The SSMSM model provides a framework in which to judge the relevancy of each variable and to provide for a side-by-side comparison of their ratings. The model allows the user to evaluate the merits of each methodology, discard those not suited to the program from further consideration, and recommend areas which might require further analysis in making the dual sourcing decision.

1. Directed Licensing

The DL methodology should not be applicable to the AAAV program because the current acquisition strategy calls for a predetermination of proprietary rights in the FSD RFP. In addition, concurrent development has provided the Government with unlimited data rights to several primary subsystems of the vehicle, including the marine drive, retractable suspension, and engine. Since the Government

will possess unlimited rights to all technical data, the DL method is not a valid method for consideration.

2. Form, Fit, and Function

The singular overriding variable that makes this methodology unacceptable for use in obtaining production competition is the organic, low echelon maintenance philosophy of the AAAV. The F3 methodology would create two "black box" versions of the vehicle, which although by definition would function identically, would nevertheless prove totally impractical to logistically support in tactical operations. Such an effort could conceivably field two versions of the vehicle with no two parts above the nut and bolt level the same. This arrangement would prove impossible to support in battlefield conditions logistically, and would also pose numerous manpower problems in providing for maintenance personnel.

3. Technical Data Package

Analysis of the TDP strategy using the SSMSM reveals that the use of this method to introduce production competition poses several areas of risk for the AAAV program. These areas are mostly weighted towards the technical aspects of the program with "particulary inappropriate" ratings given in the model for the variables of "system complexity" and "state-of-the-art". These ratings reflect the historical difficulty experienced by programs in validating TDP´s that are capable of allowing the system to be manufactured by the

second source. Since technology transfer is achieved solely on the basis of the TDP with no contractor-to-contractor dialogue, the success or failure of this strategy will depend chiefly on the quality of the TDP.

a. Delivery/Development of the Technical Data Package

An area of risk that must be considered with this method is the potential for the late delivery of the TDP which can be caused by actions of either the Government or the contractor. Dale W. Church, former Deputy Under Secretary of Defense for Research and Engineering (Acquisition Policy) stated in congressional testimony that: [Ref. 15:p. 21]

> The reason I mention validated data packages is that their development typically takes four to five years. If you wait four to five years from the start of production to go into competition with the second source, you have built so many units that there are not enough left for the second source.

One reason for this problem in complex systems is that freezing the baseline configuration of the system by the Government is extremely difficult. Upgrades and quality improvements are frequently introduced with the result that quite often timely changes to the master data package are not made. Also, the desire by engineers and the program office to field the most modern system can encourage repeated changes to the design. The inability of the program office to freeze the production design of the M-1 resulted in the TDP being delivered approximately 13 months late. This

situation can even be worsened when the contractor decides, for whatever reason, to trade-off reliability or maintainability factors during FSD in exchange for cost reductions. This was alleged to have occurred in the M-1 program when the developer was acting under the pressure of an intensive "Design to Cost" effort. This resulted in the system being fielded to meet the initial operational capability requirement and almost immediately requiring extensive design changes to correct problems. TDP validation difficulty was the common experience reported in the "lessons learned" documents published by other programs. [Ref. 21:p. F-5]

In the case of the AAV7A1, the "Physical Tear Down Logistics Demonstration" (PTLD) currently nearing completion at Marine Corps Logistics Base, Albany, Georgia, is just now completing validation of the Master Data Package three years after the last vehicle was accepted [Ref 26].

The program can also discover that the developing source may find that it is in his best interest to maintain a high rate of change. This instability can lead to a situation were competition is not possible because current, accurate, and complete data are not available. [Ref. 17:p. 63]

It is also generally impractical to provide meaningful negative or positive incentives to encourage timely delivery/upgrading of data since it is unlikely,

especially if the contractor has excess capacity, that any combination of incentives will match the amount of lost cash flow due to the introduction of competition.

b. Revolutionary and Evolutionary Systems

New state-of-the-art systems that are often revolutionary or that plan for evolutionary change as a means of cost control and fielding improved versions of the system can complicate the TDP strategy implementation. The technical nature of these systems equates them to the complex, state-of-the-art systems that the TDP strategy is not particulary suited to support. As previously discussed, the AAAV will be a revolutionary system and can be expected to encounter difficulties with design stability.

The BFV program office stated that one of the major considerations in deciding against whether the TDP strategy would be beneficial to introducing production competition in the program was the "revolutionary" nature of the vehicle, combined with the "evolutionary" character of the vehicle. The BFV was revolutionary because it departed in numerous ways, both in design and intended tactical use, from its predecessor the M113. Its character is termed evolutionary because the vehicle is expected to grow and change incorporating new advances in weapons, communications, and engineering as they are developed. An evolutionary system then is distinguished by the introduction of numerous design changes and their incorporation at a high

tempo into an upgraded system. This has occurred to a degree in the BFV that it is often reported that no two vehicles are the same. The changes that result with evolutionary and revolutionary systems make the validation and acceptance of the TDP a risk filled endeavor. [Ref 33]

c. Time Required to Implement the Strategy

Time, the short duration of the production phase, also works against the use of the TDP strategy for the AAAV program. The review of literature finds some disagreement on the earliest time that a TDP strategy might be introduced, but the general consensus is that the third year of production is about the soonest the effort should be attempted with the fourth year or thereafter the main consensus.

In only one case, the M113 where the FSD developer won the contract, did a program initiate competition from the first production award utilizing the TDP. Though this program was successful, the complexity of the system was minimal and design changes were unexpected and eventually introduced only after several years production. [Ref. 20:pp. 5-7]

Two complex systems that successfully used the TDP strategy, the AIM-7F (SPARROW) missile and the AGM-88A High Speed Anti-Radiation (HARM) missile demonstrate the usual scenario. The HARM had been developed by Texas Instruments and produced since 1982 when the dual sourcing

RFP was issued on 17 May 1984, two years after production had begun. The SPARROW missile had been produced by Raytheon since 1956 with upgraded versions introduced until 1972 when the AIM-7F was fielded. General Dynamics was established as a second source in 1974 and began head-to-head competition in 1977. A three year period was required to validate the TDP and qualify GD as the second source, with a total of five years elapsing since production of the AIM-7F first began. Though both programs are considered successful second sourcing efforts, both programs reported TDP validation and product baseline freezing as problem areas. [Refs. 14:pp. 67-79, 34:p. 31]

d. Potential Government Liability

Studies indicate that substantial Government liability may be entailed with the TDP solicitation should the TDP prove inadequate for production. Once the TDP is accepted from the developer, the Government effectively guarantees its accuracy and adequacy for production. [Ref. 27:p. 14]

In six competitive missile procurements held during the 1960´s in which the second source won a contract based on a TDP solicitation, four cases resulted in claims against the Government which ranged from $4.2 million to $40 million. The fifth case resulted in the second source experiencing a $16 million overrun which it did not claim, and in the sixth case the Government was required to pay

engineers from the developer to solve problems encountered by the second source. The result is that second source contractors have a built-in insurance policy when building to a TDP provided by the Government. [Ref. 5:pp. 49-50]

4. Leader-Follower

a. Program Risk: "A Mixed Bag"

The LF method of introducing competition is similar to the TDP method except that the complexity of the system prescribes that without the assistance of the developer, the second source would not be able to manufacture the system. This method's use in the AAAV program is supported by the SSMSM analysis due to the nature of the "complexity" and "state-of-the-art" variables and recommends that transfer of data/technology be accomplished through face-to-face exchange.

The LF method presupposes, however, the existence of a TDP adequate for competition, and may therefore experience several of the difficulties expounded upon in discussing the TDP method. Whether the LF method requires a validated TDP is subject to debate, though acquiring a validated TDP may prohibit competition because of the delays involved. These delays could result in competition no longer being feasible because insufficient production quantities remain. While the use of a TDP that has evolved from development phases may be adequate, it will increase the risks of undocumented engineering changes, schedule slippage,

and cost increases. The expertise of the leader is the factor the program office anticipates will "bridge the gap" between the production TDP and a validated TDP. The benefit of a higher assurance of technology transfer obtained from a properly executed LF strategy is what a planner expects will reduce risk to acceptable levels. [Ref. 11:pp. 45-46]

Reliance on the leader to execute technology transfer, especially in view of the ultimate consideration that the follower is soon to become a competitor, should provide ample reason for the program office to vigilantly monitor all data transfer. One program that demonstrates the potential risk that is assumed due to a LF strategy's reliance on the leader is the AIM-54C PHOENIX missile. In a report on the program's configuration management, dated 22 August 1988, the Defense Department's Inspector General has stated that: [Ref. 35:p. 330]

> In supplying factory test sets to Raytheon in preparation for dual sourcing, Hughes (Aircraft) delivered equipment for which test sets did not match drawings, parts were obsolete, specification test procedures were missing, or test instruction specification limits did not match specifications.

The Inspector General has recommended that the Navy reassess its plans for dual sourcing until the Raytheon missile completes testing in 1990.

The Navy has rebutted and nonconcurrs with the findings and affirms that the missile is ready for dual sourcing. The Navy has also stated that: [Ref. 35:p. 331]

> The assessment requested would delay the competitive award by 15 months...causing a 12 month interuption of production or require a noncompetitive contract for low rate production... causing the Navy to requalify the second source or pay the cost of maintaining a qualified production facility.

It is apparant that the risk assumed in a LF strategy is a "mixed bag" in that risk reduction is assumed through the use of the Leader´s expertise, but that blind reliance on the Leader could actually increase risk. If supervised correctly, the LF strategy can be beneficial to ensuring technology transfer, but should not be considered as a waiver for close supervision of the effort.

b. Early Potential for Production Competition

The limited production quantity of the AAAV will require that production competition be introduced early to make the effort economically justifiable. Though not recommended for short duration programs by the SSMSM, the LF methodology can be tailored to achieve this goal. A successful LF strategy could could conceivably initiate competiton in the second year of production [Ref. 16:p. 34]. The prospect of early competition dictates that a commitment to a LF strategy be made upon entering the FSD phase. This would be in line with the current acquisition strategy of contracting with a firm, other than the prime, to maintain an engineering team that participates in the development of the prime´s technical data. This strategy as currently envisioned can easily be modified to conform to the LF methodology. In addition, if it is assumed that the follower

is a firm familiar with and perhaps currently manufacturing other armor vehicles, the face-to-face exchange of technological data and production processes may provide the impetus that could assure the early qualification of the second source.

c. Program Flexibility

The LF method provides flexibility for the program by allowing time for program variables to develop before committing to a particular strategy while striking a balance between increased program risk and cost. If the program office feels that variables have developed sufficiently during CE and D&V to support an aggressive second sourcing effort, the LF strategy could be implemented upon entering FSD and the follower could learn and observe throughout this phase. This scenario of an early commitment to a LF strategy with the accompying start of technology transfer will increase the potential for early production competition.

If variables have not developed to the point where they could be used as a basis for implementing a second sourcing strategy, and the Government desires to maintain this option for further evaluation at reduced cost, the LF method could be included as an option in the FSD RFP. By doing this, the Government could receive the benefits of a fully priced option and commitment from the leader to participate in the strategy, and would have accomplished this

while the leader was still under competitive pressure for award of the FSD contract. This competitive pressure with the LF option used as a selection criteria would assist in limiting the cost of such a strategy. The ultimate decision whether or not to actually exercise the option could then be based on analysis of FSD prototyping and DT/OT II testing. If the maturity of the design, technical problems, budgetary reductions, or reduced procurement quantities indicate at the end of FSD that competition is not warranted, the Government could decide not to exercise the LF option. In either case, the possibility of competition is left open to the program to use if warranted.

d. Added Program Expense

Variables that should be considered with a LF method include the increased cost of the technology transfer, the cost of possible positive incentives/award fees to motivate the leader and encourage technology transfer, and the increased program management in managing two contractors during the technology transfer itself. Though these areas are potential disadvantages with the LF method, their effect can be minimized through early planning and commitment to the a LF strategy.

For instance, the program can include in its RFP for the FSD contract a requirement the proposals include plans for the implementation of a LF strategy. This would include both a time schedule for technology transfer and a

fully priced option for the effort. If the strategy is committed to when competition for the FSD contract still exists, the program may find that the price is not prohibitive.

The cost and use of incentives to motivate the leader should be considered by the program. It must be remembered that the leader has substantial reason for not wanting to qualify a second competitive source. To motivate the leader, positive incentives such as award fees for early qualification of the second source and for meeting technology transfer milestones is appropriate. Negative incentives can also be employed, such as reducing progress payments if technology milestones are not met. [Ref. 36:p. 17]

e. Increased Management Requirements

Throughout the preparation for the FSD and production phases the program office may feel that it has few or inadequate resources to meet all the commitments that are transpiring. The LF methodology may well require the most continuous supervision of any of the five second sourcing methods, and may further strain the resources of the program staff. Reasons for this include the time, effort, and cost necessary to meet the following requirements:

1. To analyze and select which of three contracting methods to use in implementing the LF strategy.
2. If the Government chooses the follower, effort will be required to solicit and award the contract.

3. If the leader is permitted to choose the follower, resources will be expended to review and confirm the selection.
4. Monitoring the progress of the LF team in meeting the milestones of the technology transfer plan.
5. Preparing for and reviewing the follower production qualification which may include first article testing.

Though the use of an LF strategy has some obstacles or costs that must be resolved with the available program resources, none appear at this moment to be insurmountable. The key factor may well prove to be early planning and commitment to the strategy prior to entering FSD. An examination of successful programs employing a LF strategy noted the following essential characteristics: [Ref. 11:pp. 47-48]

1. First year production of the system by the developer-leader, during which time the TDP is validated.

2. Concurrent with release of the first production equipment, a competition among established producers for selection of a second source.

3. Award of an educational buy with option provisions to the follower to enable him to become proficient in manufacturing the hardware.

4. Follower production of a small quantity of items for qualification testing, with technical assistance furnished by the leader.

5. Exercise of option by the Government so that the follower can demonstrate his capability to achieve quantity production.

6. Split buy awards between the leader and follower.

7. Winner-take-all, buy-out competition for remaining production quantities.

5. Contractor Teaming

Analysis of the Contract Teaming strategy using the SSMSM suggests that this method of introducing production competition may present several advantages for the AAAV program. These advantages include increased effectiveness of the technology transfer, greater flexibility in the acquisition strategy implementation, earlier implementation of production competition, and reduced Government liability for design specifications.

The disadvantages that may be experienced with this strategy include schedule slippage, increased Government management required to supervise two contractors, possible program cost increases, and possible reluctance of the team members to split for production competition. In addition, the primary disadvantage is that a commitment to the CT strategy must be made at the latest upon entering FSD, and once the team is formed, it may well prove impractical to split the team if difficulties with the arrangement develop.

a. Program Flexibility, But at a Price

The primary advantage received from the CT method is the flexibility that it provides the acquisition strategy in regards to achieving production competition, but at the price of commitment to the strategy early in the acquisition process. The acquisition strategy currently plans for design

competition to end upon entering the FSD phase, with the ultimate result as previously discussed that any possibility for production competition will rest with either the high risk use of a TDP strategy, or the moderate risk associated with the use of a LF strategy. A major recommendation of all the programs reviewed, and a current desire of the AAAV program, has been to continue design competition and increase the possibility of production competition by maintaining two contractors through the FSD phase if funding permits. The CT method achieves part and perhaps all of this goal.

Should it be determined as program variables firm up during FSD that dual productions sources are not economically feasible, the program office would retain the option of competitively awarding a sole source contract based on a production RFP to team members. Under this situation the use of production options or a multiyear contract for the full duration of the production contract could prove beneficial in securing the benefits of competition throughout the production. The use of a four year multiyear contract on the AAV7 program in 1970 as previously discussed resulted in a price behavior indicative of a 97% progress curve. It would be reasonable to assume that this price behavior could be equalled or improved upon with two experienced contractors in competition for a winner-take-all award. The decision could also be made to keep the team together to certify two production sources for industrial base or surge

considerations and have each contractor manufacture those systems with which it has the most experience. Such a strategy is currently envisioned by the ATA program where splitting the team is not presently envisioned [Ref. 37].

b. Program Cost

Cost increases in a teaming arrangement are possible since the program office finds itself dealing with two contractors. This means the possibility exists that the Government may find itself paying for two overhead rates, design efforts, additional travel, profit, and other similar expenses.

Design, overhead rates and profit for two contractors have not currently generated cost increases on programs utilizing the CT method primarily because of the decision by team members to employ a joint venture teaming arrangement over the use of a prime contractor/subcontractor teaming arrangement. The advantage of the former over the latter teaming arrangement stems from its incorporation of single amounts for overhead rates and profit for the new financial entity formed through the joint venture. In the latter method the likelihood that the prime will place overhead and profit on top of its team members overhead and profit is increased. This situation was encountered in the ATA program where Northrop, Grumman, and LTV (N/G/L) teamed, with Northrop as the prime and Grumman and LTV as subcontractors. In proposals submitted in response to RFP´s,

Northrop placed its own overhead and profit on top of that submitted by subcontractor team members. This factor was identified as a contributor to the N/G/L proposal being priced higher than the GD/MCD proposal. Since GD/MCD won the FSD contract the program has experienced no cost increase due to these factors. [Ref. 37]

The ATF program which is utilizing a CT strategy, also in a prime/subcontractor teaming arrangement, reports no program cost increase due to its use of firm fixed-price contracts during CE and D&V phases. The program office reported that they budgeted for fixed amounts of funding for each contractor and awarded contracts that did not exceed the budgeted amounts. However, it was freely admitted that the teams are spending perhaps as much as 50% more on development than funded for in the contract. It may prove impractical though for other programs to use fixed-price type contracts for development work as the ATF did because program and industry variables may be considerably different. [Ref. 38]

Interviews with Business Financial Managers from the V-22 and ATA programs characterize any cost increases experienced as minor, but neither could accurately quantify the amount. The ATA program expressed an opinion that no or only insignificant additional costs were attributed to the teaming strategy, while the V-22 program reported that the only identifiable cost increase was for additional office

space rented for the establishment of a joint office in the Washington D.C. area for the Bell/Boeing team. [Refs. 37, 39]

c. Increased Quality of Technology Transfer

The technological aspects of the program, in particular the "complexity" and the "state-of-the-art" variables, have ratings that indicate that this method is particulary suited for application in the program. This method has been used by other programs of equal or greater complexity, ATA, ATF, V-22, and ASPJ (Airborne Self Protection Jammer), with satisfactory results to date.

A major factor in the establishment of production competition is the quality of the technology transfer. With the CT method, the technology transfer is enhanced through direct contractor-to-contractor exchange of information between contractors who have worked together, most likely for several years, and who are familiar with the partner´s methods. No other methodology theoretically provides the quality of learning that is experienced by both contractors than the CT strategy where both participate in design and test efforts. Even in the use of the LF method, which in accordance with the FAR is used only when the complexity of the system warrants direct contractor-to-contractor technology transfer, the question of the leader´s motivation to teach the follower arises. Though the possibility exists that as the point of splitting the team approaches one

contractor may withhold technology from the other in an attempt to gain an advantage in production, both the V-22 and ATA programs report great satisfaction with technology transfer to date. [Refs. 37, 39, 40:p. 27]

d. Increased Potential for Design Innovation

Maintaining two contractors through FSD may deliver several advantages to the program in regards to design innovation. First, there is the synergistic effect that may be experienced by two contractors working together with complimentary skills. This should be especially noticeable during the D&V phase when contract teams are still competing against one another for award of the FSD contract. Once into FSD the team will still have two sets of views/outlooks from which to approach design efforts. Second, it is reasonable to assume that each contractor will have certain areas of expertise that should compliment the partner. This expertise may provide faster more innovative answers to problems that are encountered throughout testing.

The emergence and use of complimentary skills is one of the observed strengths on both the V-22 and ATA programs. In the ATA program, MCD possesses experience with the design and manufacturing requirements for aircraft that are capable of landing on aircraft carriers, while GD possesses experience with aspects of state-of-the-art "stealth" technology [Ref. 37]. In the V-22 program, Boeing has experience in designing conventional fixed wing aircraft,

while Bell´s area of experience centers on helicopters. This combination of capabilities was advantageous to designing a system that demonstrates the performance capabilities of both a fixed-wing aircraft and a helicopter [Refs. 39, 40:p. 28].

e. Earliest Potential for Production Competition

As previously mentioned, technical data alone has often proved insufficient in providing a contractor with all the knowledge required to build a system. A primary advantage gained with the CT method is that production "know how" is also developed and transferred through the prototyping subphase of FSD. The joint qualification of production sources resulting from the co-development effort presents the possibility of competition earlier than any other method and at a level of substantially reduced risk.

The V-22 program which is scheduled to begin production during March 1990 currently plans for head-to-head competition to begin with the second year´s award. The first year´s production of 12 aircraft will be split so that the team manufactures the first eight aircraft to validate the design and manufacturing processes, and the individual team members to solely produce two of the remaining four aircraft to qualify as production sources. The limited quantity of aircraft produced during the first year´s production, between one and two per cent of the planned procurement, also leaves ample quantities of production aircraft for competition in follow on years. [Ref. 39]

f. Decreased Government Liability

In soliciting for a second source utilizing design specifications contained in a Level III TDP, the Government assumes liability that the data are sufficient to perform the contract. The CT method reduces or eliminates the Government's potential liability because both potential sources developed the data. It will prove difficult for a contractor to make a substantial claim for equitable adjustment for design flaws or the inclusion of inappropriate production processes which it helped develop or recommend.

g. Potential Schedule Slippage

Though all the programs interviewed reported no schedule slippage caused directly by the teaming strategy, the V-22 program reported an impression of delay in the team making "timely decisions". This was believed to have occurred because executives in the joint venture were occasionally "dual hatted" and held positions in both the joint venture and their parent corporate structure. This meant that issues had to be resolved first at the team level in Washington D.C., then are often referred to corporate level for review, and finally may have entailed reconciliation between corporate headquarters for a final decision. The primary reason given credit that schedule slippage has not occurred is that the teaming agreement between the contractors specifies who is ultimately responsible for each subsystem, i.e., Bell has responsibility

for the wing components and Boeing has responsibility for fuselage components. Though discussions are required between team members to keep appraised of current situations, the final authority for decisions on a particular subsystem rests with only one corporation allowing that team member to make the necessary decisions. [Ref. 39]

h. Program Management

Program office´s have expressed an opinion that managing a program with a teaming strategy is a more complex and demanding effort. Though they could not quantify this variable, matters that surfaced as potential problems included dealing with two or more sets of management structures, dealing with the geographic dispersion of the team member´s home offices regardless of the joint venture office in Washington, and dealing with two different Defense Contract Administration Services (DCAS) offices or Plant Representative Offices in different DCAS regions. Though their opinions expressed that managing the teaming effort was more complex than other program methods that may have been employed, no program would change the teaming strategy if presented another opportunity to reconstruct the acquisition strategy. [Refs. 37, 38, 39]

i. Reluctance to Compete

A new phenomenon that may arise out of the CT methodology is the reluctance of team members to split for competition. As the completion of a program´s FSD phase

draws near, the program office may find that the team members are not in favor of splitting the team and competing head-to-head. The team may find many reasons for this and may talk to as many officials in authority as will listen in an effort to stop the planned team split and the eventual start of production competition. This is the case currently with the V-22 program where the Bell/Boeing team has expressed a strong opinion that the team should not be split. The dominant reason given is that the team believes it may be better able to compete in the world market against international competitors. What is being observed is that the team may find the present contractual arrangement better than the approaching competitive option and may attempt to exercise the monopolistic power of a sole source. The program office still plans for production of the V-22 to begin in March 1990 with a split of the team for the second year of production. It does not envision that discussions about this topic will subside and believes that more time and effort will have to be expended discussing this option. [Ref. 39]

C. RESULTS OF SECOND SOURCING METHOD SELECTION MODEL

1. Critical Program Variables

Analysis of program variables indicates that five variables are particulary significant to the second sourcing decision of the AAAV. These variables are the economic variables of "quantity", "duration", and "tooling cost", and

the technical variables of "complexity and "state-of-the-art".

The economic variables of "quantity" and "duration" clearly indicate that a methodology that can introduce competition early in production is mandated. If competition is attempted three to four years after the production decision, insufficient quantities will be available to recoup the expense. The "tooling cost" is identified as a variable that must be firmed up to permit an accurate economic analysis. The difference between $50 million and $238 million warrants greater attention and confirmation as design and manufacturing requirements are defined.

The technical variables of "complexity" and "state-of-the-art" indicate that a methodology that decreases the risk of technology transfer is warranted. Historical problems in obtaining accurate TDP´s, and the rate of design/engineering changes experienced by new systems will require face-to-face contractor exchange of data.

2. Comparision of Probable Second Sourcing Methodologies

Analysis of the established second sourcing methods indicate that either the LF or CT methods present a higher probability of meeting the criteria established by the program variables, yet only one method can be followed. In comparing the two methods it is best to analyze them against how they meet the critical variables identified above.

In regards to the economic variables, the CT method receives higher ratings than does the LF method, with the CT method receiving "neutral" ratings and the LF method receiving "inappropriate" ratings. This apparently reflects the ability of the CT method to introduce production competition earlier than the LF method and reflects the constraints imposed by the low production quantity and short production duration. The CT method then permits a more favorable opportunity, with less risk, for the recoupment of cost incurred in establishing the competitive environment.

In regards to the technical variables, the CT method again receives higher ratings than the LF method, with the CT method receiving ratings of "particulary appropriate", and the LF method receiving ratings of "appropriate". Though both methods reflect suitability for establishing competition, these variables indicate that additional benefit from participation in the systems development process can be obtained from the CT method. This is achieved by the participation of both contractors in the development phases and the subsequent reduction of the risk involved with the technology transfer.

3. Recommended Second Sourcing Methodology

After analysis of the critical variables that have the potential for major impact on the procurement scenario for the AAAV program, and the comparison of ratings between these variables, the use of the CT methodology is

recommended. This method presents advantages that minimize the risks inherent with technology transfer and better addresses the limiting economic variables which constrain the use of other methods. The CT method presents the greater possibility of success for the program while minimizing risk exposure. In addition, since production competition is a stated goal of the AAAV program the early commitment required by a CT strategy should not pose a problem if an economic analysis indicates that production competition is justified in terms of projected monetary savings.

D. SUMMARY

This chapter presented an analysis of the economic, technical, and management variables of the AAAV program, and identified those critical variables that could have a significant impact on the program. An analysis was then performed which presented several possible advantages and disadvantages associated with the use of each of the five second sourcing methodologies. A recommendation was also made that the Contractor Teaming method offered the most credible method of introducing production competition. In Chapter VII an economic analysis will be performed which will present possible monetary costs and savings which could be realized from pursuing the CT approach.

VII. ECONOMIC ANALYSIS OF SECOND SOURCE PRODUCTION

A. INTRODUCTION

In analyzing whether production competition is warranted on an economic basis, the program manager must determine whether the projected savings from competition between two production sources provides sufficient savings in production costs to recover the additional program costs of establishing the second source. These additional costs include the increased program costs of soliciting and managing two sources, technology transfer costs, and primarily the cost of the industrial facilities required by the second source [Ref. 4:p. 1-17].

As was described in Chapter II, the anticipated savings from production competition result from an observed shift and rotation of the progress curve once competition is introduced, or once the threat of competition is considered viable by the first source. An economic analysis can be made using this observation by varying the progress curves for dual sources and analyzing the effect of increasing the rate of learning.

B. COST EQUATIONS

Using the progress curve concept, the individual cost of a given numbered unit, i.e., 1000th, produced during a

production which demonstrates a progress curve can be determined from the equation: [Ref. 4:p. D-7]

$$Z = A * X^{B} \qquad \text{(Equation 1)}$$

Where Z = Cost of the Xth. unit
A = Cost of the first unit
X = Cumulative quantity produced
B = Log (progress curve)/Log (2)

Since this equation demonstrates a continuous function, integration can be performed which provides an equation for determining the area under the progress curve. This area represents the cumulative cost of a given production lot or of the entire production contract. This equation is: [Ref. 4:p. D-10]

$$C(K,N) = (A/B+1)[N^{B+1} - K^{B+1}] \qquad \text{(Equation 2)}$$

Where A = Cost of the first unit
N = Number of the last unit of a period
K = Number of the first unit of a period
B = Log (progress curve)/Log (2)

The use of Equation 2 is sufficient to determine the cost of a program when the contractor(s) demonstrate a progress curve from the first unit produced and expect this curve to continue throughout the production. With this formula, a hypothetical competitive environment can be constructed which will estimate the probable effect of competition on production costs by introducing variations in the slopes of progress curves for two competitors.

C. FIRST UNIT "ROLLAWAY" PRICE

As indicated by the previous equations, the first piece of data required to perform an economic analysis on the possible effect of competition on a program is the expected first unit cost of the system.

A Life Cycle Cost Estimate performed by Advanced Technologies Inc. on 11 May 1988 for the AAAV program office provided information which permits the determination of a probable first unit "rollaway" cost for a hypothetical AAAV [Ref. 30:p. 1-9]. Table V demonstrates the computation of the projected first unit production cost.

D. COST OF ESTABLISHING A SECOND SOURCE

The cost of establishing a second source is the sum of the non-recurring costs for industrial facilities and special test equipment, and the recurring cost of any additional program management expected due to the increased program size. For the AAAV program the cost of establishing a second source is estimated to be $74-$262 million. The basis of this estimate follows.

1. Industrial Facilities

As previously discussed, this cost for the program is expected to fall between $50 million and $238 million for a facility capable of a production rate of 30-35 vehicles per month. Normally in a dual sourcing effort the two sources are facilitized at a rate approximately 60-70% of the planned production rate. This facilitization provides both

TABLE V

LIFE CYCLE COST ESTIMATE (LCCE) FIRST UNIT COST CONVERSION

HARDWARE ELEMENTS	*LCCE COST	PROGRESS CURVE	FIRST UNIT COST
HULL AND FRAME	168,779	.9288	352,370
SUSPENSION	133,540	.9639	192,639
PROPULSION PLANT	231,216	.9548	362,316
AUTOMOTIVE DRIVE	325,316	.9345	639,007
MARINE DRIVE	334,594	.96	502,573
AUXILIARY SYSTEMS	211,517	1.00	211,517
TURRET ASSEMBLY	116,628	.918	273,593
ARMAMENT	74,638	.96	112,109
NAVIGATION AND COMMUNICATION	133,195	1.00	133,195
FIRE CONTROL	339,489	.96	509,926
INTEGRATION AND ASSEMBLY	60,288	1.00	60,288
TOTAL HARDWARE COST PER VEH.			3,349,533
NON-HARDWARE ELEMENTS			
INDUSTRIAL FACILITIES	50,000,000		36,364 PER VEH.
SYSTEM TEST AND EVALUATION	25,737,000		18,718 PER VEH.
PROGRAM MANAGEMENT	49,121,000		35,723 PER VEH.
ENGINEERING CHANGES	110,597,000		80,434 PER VEH.
TOTAL NON-HARDWARE COST			171,230 PER VEH.
TOTAL COST PER VEH.			3,520,763
TOTAL VEHICLE COST (INCLUDING 10% PROFIT)			3,872,839

Note: -LCCE costs were computed at the 1000th. unit cost using the indicated progress curve factor.

-All costs of production were included in the LCCE estimate except profit. The profit shown was added to allow for its the cost to the Government and can be changed for comparison purposes.

-Progress curves used in the LCCE estimate were obtained from various cost models which include the Fighting Vehicle Cost Estimate, Tracked Vehicle Resource and Display Model (TREAD), and the Landing Vehicle Tracked Experimental (LVTX) Cost Estimate.

Source: Developed by the Researcher
* Source: Preliminary Life Cycle Cost Estimate, 1988.

contractors the capacity to compete for up to 70% of any year's production award, and saves the Government the cost of facilitizing both contractors to 100% of the planned rate. It still, however, entails additional cost to the program because the Government has paid for facilities capable of producing at a rate equal to 130-140% of planned buys.

For the AAAV program this would imply that the cost of facilitization should be 30-40% higher than the cost of the facilities estimate for a sole source, and that production sources should be facilitized at a rate of 21-25 vehicles per month (60-70% of the monthly rate). If this is possible, it would reduce the cost to the Government of introducing production competition and make the dual sourcing decision more favorable. This may not, however, be feasible on the AAAV program since the production rate planned for is low by commodity standards. The difficulty the program may face can be explained in the following manner. The machinery that is required to produce the vehicle has certain inherent capabilities that come with it; if one piece of equipment has the capability of welding 30 hulls together per month, and this is the smallest piece of equipment suitable for the work, then it is not possible for less than one welder to be procured. This means that two welders must be bought to do the work that one would be capable of in a single plant. The rate of 30-35 vehicles per month appears to be close to the point where the Government will have to facilitize both

contractors at 100% of planned capacity to have dual sources. If this situation occurs, it means that an additional production source will cost another $50 million to $238 million for facilities. [Ref. 31]

2. Program Management

The use of two contractors for production means the Government must pay for the increase effort in managing two contractors, and the additional management structure of the second production source. For the Government this might entail additional personnel for the program office, additional travel expenses, the cost of award fees/incentives if used, and the added cost to the Government of having two DCAS offices dealing with two production sources. The current estimate for program management cost contained in the LCCE is $49.1 million [Ref. 30:p. 1-12]. A detailed analysis of this cost will depend on the second sourcing methodology planned for use, and the nature and content of the contract itself. Since no other method of calculating this cost presents itself, it will be assumed that a 50% increase in funding will be required for increased management. This reflects an increase of approximately $23.5 million.

E. SENSITIVITY ANALYSIS OF SECOND SOURCING

1. General

Appendix C presents a sensitivity analysis which reflects the probable monetary effects on the AAAV program assuming the implementation of a CT strategy. As in any

analysis, the projection of possible events can be dramatically altered by entering either, optimistic, most likely, or pessimistic variables into the equation. In evaluating these projections it is helpful to remember that: [Refs. 20:p. 14, 22:p. 52]

1. The previous production of the AAV7 family demonstrated a 97% progress curve over four years utilizing one, four year multiyear contract.

2. That the general price history of armor vehicles without the pressure of production competition has been notably upwards.

3. The most favorable progress curve demonstrated in the data is for the M113 which produced a 91% progress curve over a 12 year period.

2. Contractor Teaming Economic Analysis Summary

The sensitivity analysis for a CT strategy provides promising cost data for employing this strategy. At the flattest end of the progress curve spectrum for a hypothetical sole source, i.e., 97-100%, a one per cent increase for both sources in learning due to competition results in production cost savings of approximately $485 million at 100%, and $254 million at 97% . When an optimistic expectation is considered and a learning increase of 8-10% is employed, the program could realize production cost savings of $3.4 billion at 100%, and $2 billion at 97%.

At the steeper ends of what has been historically demonstrated for this commodity´s progress curve for a hypothetical sole source, i.e., 91-94%, a 1.5% increase in learning results in approximate production cost savings of

$238 million at 94%, and $215 million at 91%.

In projecting the monetary savings presented in Appendix C, no allowance was made for the cost of establishing the competitive environment. However, it is apparent that even assuming the worst case scenario of approximately $262 million dollars for increased program costs incurred from introducing competition, that a second sourcing effort is economically justifiable.

F. SUMMARY

This chapter presented information which allowed for the determination of a "probable" First Unit Cost for the AAAV, and range of values for the "probable" costs associated with developing a second production source for the AAAV program. This information, when used with equation 2, enabled an economic analysis to be performed. This analysis, presented in Appendix C, indicated that minor increases in the progress curve caused by the introduction of production competition could offer significant savings in total production costs to the Government.

VIII. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The focus of this research effort was to study the effects of competition in the acquisition of weapon systems, identify issues/variables that may affect the use of a competitive strategy, identify competitive strategies that are suitable for introducing competition into a program, and evaluate these strategies as they apply to the U.S. Marine Corps AAAV program. Based on this study the following conclusions are made.

1. <u>The use of design competition appears to stimulate those efforts associated with designing the system, but may result in higher production prices later by encouraging the use of "buy-in" strategies by contractors if only one contractor is carried forward into FSD.</u>

Design competition encourages innovation during the design phase, but may encourage the use of "buy-in" strategies by contractors if only one contractor is carried forward into FSD for full system development. As in the M-1 program, cost may begin to escalate once competition is in the past and opportunities begin to present themselves for the contractor to request price increases. A goal of the program should be to carry two contractors through FSD to

maintain the benefits of competition as long as possible.

2. <u>The introduction of production competition into the acquisition of weapon systems results in a pattern of unit price reductions.</u>

The body of available research generally supports the hypothesis that the introduction of production competition will deliver reduced unit prices. A repeated pattern of increased learning, indicated by a shift and rotation of the progress curve when competition is introduced, has been observed on a predominance of programs. This increase in learning translates into price reductions in the out years of the program, and delivers immediate savings relative to the degree of shift experienced with the progress curve. Savings also appear to be greater when a winner-take-all award vice a split-buy award is made.

3. <u>The Second Source Method Selection Model presents a coherent system for identifying and evaluating variables that may affect the second sourcing decision.</u>

The SSMSM has identified several variables that will be critical factors in evaluating the second sourcing decision. Chapter VI discussed how these variables relate to the AAAV program and identified several variables as potential factors that may increase the risk of the second sourcing decision. In the economic area, they include the small procurement quantity and the short duration of the production phase coupled with the small production rate which may require

tooling both sources to 100% of capacity. In the technical area, the variables of "state-of-the-art" and "complexity" indicate that the technology transfer may require a second sourcing method that both minimizes the risk associated with the technology transfer, and qualifies a second source as soon as possible.

4. <u>The varied characteristics of different commodities makes comparisons dealing with the effects of competition between commodities difficult.</u>

The majority of research performed on the effects of competition have been with missiles and other electronic systems. The characteristics of these systems regarding size, complexity, the possibility of utilizing the technology arising from their development in commercial enterprises, and the industrial base supporting the commodity make comparisons between commodities an imprecise effort.

5. <u>The Automotive commodity body of research is limited, but suggests that the commodity responds to competition with lower unit prices, and to the lack of competition with higher unit prices over the long run.</u>

The small body of research conducted to date on automotive commodities such as armor vehicles makes analysis difficult. The data suggest, however, though that Automotive commodities do respond to a competitive environment in a manner similar to other commodities. The most important fact observed from the data is that in the absence of competition

Automotive commodities seem to exhibit a pattern of unit price increases over the life of the program, rather than the increased learning and reduced prices often associated with other commodities. Without some restraining factor the AAAV program should not expect unit price decreases over the production phase, but should plan for the definite possibility of unit cost escalation.

6. <u>Early planning and commitment to an acquisition strategy directed towards achieving a second production source is critical to the success of the effort.</u>

The successful implementation of a second sourcing effort begins with early planning and commitment to a suitable strategy. Issues such as data rights, funding, preparation of Technical Data Packages, solicitation and contracting with the second source, and the qualification of a second source, are only a few of the issues that must be resolved. If not planned for during the early phases of the acquisition cycle in CE and D&V, the lost opportunities to negotiate for data, request and evaluate technology transfer plans, and commit developers to the second sourcing effort while still under the pressure of design competition will be lost. Programs that have experienced difficulty with establishing production competition generally have done so because of decisions made years before which closed off certain avenues.

7. <u>The SSMSM recommendation of employing Contractor Teaming methodology is valid.</u>

An evaluation of the AAAV program variables using the SSMSM indicates that the most beneficial methodology for introducing competition is the Contractor Teaming method. This evaluation appears to adequately address the weaknesses and risks associated with the program and offers the best chance of achieving production competition. This is primarily because this methodology reduces the risk of technology transfer and offers the potential qualification of the second source earlier in production with the resulting capability of generating greater savings.

8. <u>The extent of possible combinations of variables, in concert with their numerous possible values makes meaningful economic analysis of the affect of developing production competition uncertain, but nevertheless can still be effectively used to evaluate and judge the risk to the program.</u>

Performing an economic analysis judging whether the projected savings from competition warrant the effort and risk connected with the second sourcing effort is an uncertain endeavor which results in monetary values of dubious merit. However, if the analysis is geared instead to evaluating the necessary magnitude of change associated with the progress curve once competition is introduced, it can be a useful tool in evaluating the risk assumed by the program.

This is to say that, if the analysis reveals that a one or two per cent increase in the progress curve is enough to recover the investment costs, then this case clearly warrants more consideration and analysis than the case which requires a much greater change in the progress curve.

B. RECOMMENDATIONS

1. <u>That the AAAV program commit to a Contractor Teaming strategy early in the acquisition cycle</u>.

The Contractor Teaming methodology offers the most benefits to the program while minimizing the risks associated with developing production competition.

2. <u>That the program office maintain liaison with other programs employing the Contractor Teaming strategy to follow the progress of other programs and learn from their experiences.</u>

Numerous programs of equal or greater complexity and size are currently employing a Contractor Teaming strategy. These programs include the ATF, ATA, V-22, ASPJ, LHX, AAWS-M and the INEWS. Though none of these programs has reached Milestone III and began full production, all are ahead of the AAAV program and may possess valuable and timely information.

3. <u>That as the design of the AAAV stabilizes the program office take steps to tighten estimates of variables that may have a major impact on determining whether a final commitment to dual sources is warranted.</u>

Two such variables are the facilitation costs and the quantity of vehicles to be produced. Concurrent with the FSD phase, a requirement exists for a reliable estimate of facilitation costs. The difference between the $50 million suggested by FMC, and the $238 million suggested through parametric estimates is obviously a significant spread that must be resolved. In addition, the quantity to be produced must be confirmed. The Marine Corps´ need for 1500 vehicles is a solid estimate based on past experience and identified task organization requirements. However, an additional requirement for 300-500 vehicles for foreign military sales to any of the countries which will need to replace their aging AAV5 and AAV7 vehicles may make a significant difference to any analysis due to the low rate of production planned. During FSD, foreign military sales representatives at Headquarters, Marine Corps should endeavor to determine the most likely estimate of this variable.

C. ANSWERS TO RESEARCH QUESTIONS

1. How might competitive procurement methodologies be incorporated in the AAAV program´s acquisition strategy?

Competitive procurement methodologies can be implemented into the AAAV program´s acquisition strategy in several ways. During the CE phase, design competition will provide the program with a variety of possible alternatives to evaluate. Promising alternatives may be carried forward into D&V for

further development and subjected to prototyping followed by a "rolloff" competition. The best design from prototype competition will then be chosen for entry into FSD where it will be refined and tested for possible production.

To maintain the option of production competition, the program must make early decisions regarding data rights and in particular the methodology that offers the best chance of success. This should entail encouraging the solicitation and award of contracts to Contractor Teams entering CE and D&V, but no later than FSD. This method will provide for the greatest number of contractors participation in the program for a minimal cost increase. The use of Contractor Teams will provide the greatest possibility of production competition even if only for the first production award.

2. What is the AAAV program's acquisition strategy at this time?

Chapter V discusses the current AAAV acquisition strategy. In summary the strategy calls for design competition in both the CE and D&V phases, but will carry forward only one contractor into FSD. The strategy plans for full use of prototypes as encouraged by both DODD 5000.1 and the Packard Commission.

Current planned options for production competition rest on either the TDP or LF methods. The decision regarding the use of either method will depend on analysis of pertinent variables as the program matures.

3. What are the competitive issues that must be considered in evaluating, formulating and executing a competitive strategy?

Chapter VI discusses the primary variables dealing with economic, technical, and program management areas.

Chapter IV highlights the major issue that this research has revealed. This is that in the absence of competition, or the threat of competition, armor vehicles have demonstrated a marked and consistent tendency to increase in unit price throughout the production phase. This issue can greatly complicate the second sourcing decision in that not only must the potential benefit of reduced prices be evaluated, but also the risk of cost escalation should competition not be maintained.

4. If competitive procurement can be employed, what method(s) will deliver the maximum benefits and probability of success to the program?

This research has indicated that the Contractor Teaming method delivers the most benefits and highest probability of success, while simultaneously reducing the risk exposure of the program. As discussed in Chapter VI, this method provides for several advantages.

An increased level of flexibility is afforded the program including the option of real production competition between the team members. This can be realized by either a winner-take-all award or split buy awards for production contracts.

This is expected because both team members have been through FSD and are thoroughly familiar with the program and it can be assumed that they would desire to win the production contract.

An increase in the quality of technology transfer can be expected since both contractors would have been involved with the program for a minimum of the four years associated with the FSD phase. Also, the experience received from being involved with the prototyping effort and the knowledge received through participation in DT/OT II testing can be expected to be significantly greater than would be experienced with either the LF or TDP methods.

The Contractor Teaming method also suggests that it may entail the least cost risk/exposure than any other method. This is because the government reduces its liability for defective design specifications and is not required to provide contract incentives or pay for a LF contract for technology transfer.

The potential also exists for the earlier qualification of a second source. Due to the expected small quantities and short duration of the production contract production competition will have to be initiated from at least the second year to be financially justifiable. It is also highly improbable that Congress would be willing to fund two production sources with only two years left in the production. Under such a circumstance it would be

considerably safer for the program to request, and Congress to grant, multiyear funding authority.

An increase in the quality of the design effort can be expected from two contractors working together especially during the competitive phases early in the acquisition cycle.

D. AREAS FOR FURTHER RESEARCH

The AAAV program has the potential of costing five to six billion dollars in production costs, and having a Life Cycle Cost of nearly $20 billion. The use of production competition at the prime contractor level is one method of attempting to stabilize and reduce prices. Other methods that might benefit this program and should be the basis for further research are "Component Breakout" and "Design to Cost".

Component Breakout would encourage development of competition at the subcontractor level with the goal of reducing prices for subsystems of the AAAV which would be provided to the prime as Government Furnished Equipment (GFE). Research in this area would also benefit the Life Cycle Cost aspects of the system. Historical trends have indicated that replacement parts for the AAV7A1 have been of questionable quality and priced severely above what the parts lists have indicated. Component Breakout also has the potential of being used in conjunction with production competition for greater savings.

Design to Cost requirements are a DOD requirement for major weapon systems. Since the AAAV program is currently planning for design competition, research in this area might benefit the programs cost reduction efforts by directing the energy of contractors to designing a less costly system than the $3.8 million per unit system currently envisioned. This concept has historical backing in that the AAV7 family produced during the 1970´s, and which replaced the AAV5 family produced in the 1950´s, cost $19 thousand less per unit. This is a 15% reduction in price without taking inflation of the 1970 dollars into account.

APPENDIX A

COMPARISON OF FREE MARKET AND DEFENSE MARKET

Free-Market Theory	Defense Market
Many small buyers	One buyer (DOD)
Many small suppliers	Very few suppliers
All items small, perfectly divisible, and in large quantities	One ship built every few years for millions of dollars each
Market sets price	Monopoly or oligopoly pricing, or "buy-in" to "available" dollars
Free movement in and out of market	Extensive barriers to entry and exit
Prices set by marginal costs	Prices proportional to total costs
Prices fall with reduced demand	Prices rise with reduced demand
Supply adjusts to demand	Large excess capacity
Labor highly mobile	Greatly diminished labor mobility
Decreasing or constant returns to scale	Increasing returns to scale in region of interest
Market shifts rapidly to changes in supply and demand	7-10 years to develop a new system, then 3-5 years to produce it
Market smoothly reaches equilibrium	Erratic changes from year to year
General equilibrium-assumes prices will return to their equilibrium value	Costs have been rising at approximately 5% per year (excluding inflation)

Profits equalized across the economy	Wide and consistent profit variations between sectors; even wider between firms
Perfect mobility of capital (money)	Heavy debt, difficulty borrowing
Mobility of capital (equipment) to changing demands	Capital equipment locks in companies
No government involvement	Government is regulator, specifier, banker, judge of claims, etc.
Selection based on price	Selection often based on politics, or sole source, or negotiation
No externalities	All businesses working for DOD must satisfy requirements of OSHA, EEO, SBA, etc.
Prices fixed by market	Incentive and Cost pricing often seen
All products of a given type are the same	Essentially, each producer´s products are unique
Competition is for share of market	Competition is frequently for all or none of market
Production is for inventory	Production occurs after sale is made
Size of market established by buyers and sellers	Size of market established by third party (Congress) through the budget
Demand sensitive to price	Demand "threat" sensitive
Equal technology throughout	Competitive technologies industry

Relatively stable, multiyear commitments	Annual commitments, with frequent changes
Benefits of the purchase go to the buyer	Public good
Buyer has the choice of spending or saving for a later purchase	DOD must spend its annual congressional authorization

Source: Thomas E. Bruns, LTC. USA, Competition in Contracting Act: Free Market Illusion, 1987.

APPENDIX B

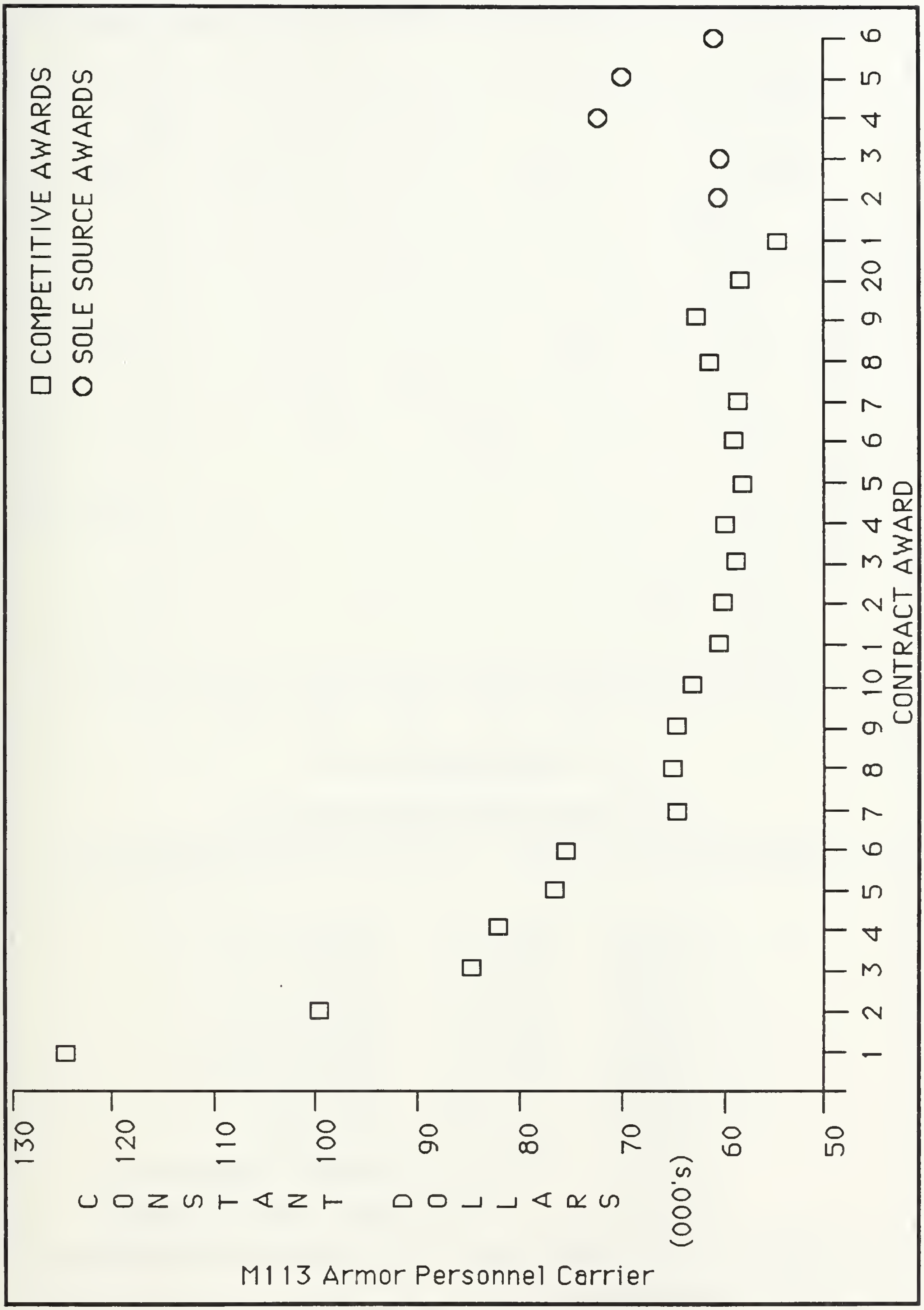
PRICING HISTORY OF AUTOMOTIVE COMMODITIES

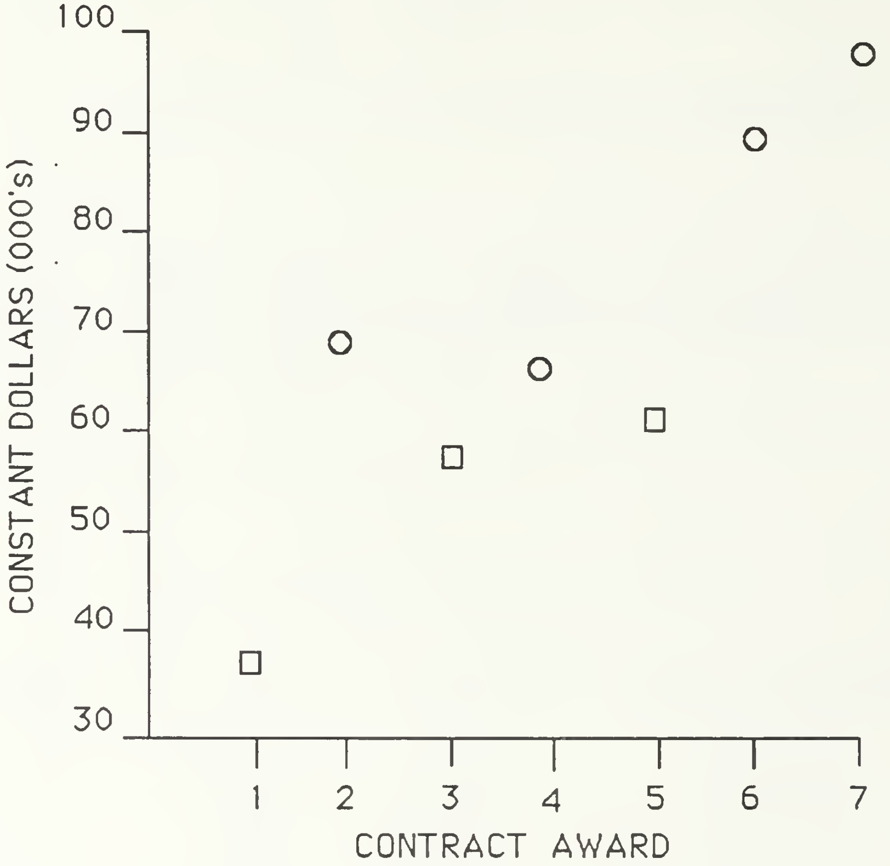
1. All contract pricing data found in the Tables in Appendix B were obtained from: U.S. Tank-Automotive Command, Competition in Automotive Commodities: Implications for Competitive and Non-Competitive Acquisition, by Patrick N. Watkins, September 1982.

2. All graphs in Appendix B were developed by the researcher from the data obtained above.

M113 ARMOR PERSONNEL CARRIER

CONTRACT	FY	QTY	DEC 80 CONSTANT DOLLARS	
1	59	375	125,683	(C)
2	59	525	99,041	(C)
3	60	874	85,676	(C)
4	61	806	83,520	(C)
5	61	1500	77,677	(C)
6	62	1500	77,191	(C)
7	62	1632	64,007	(C)
8	62	1132	64,494	(C)
9	62	1200	64,007	(C)
10	62	694	61,425	(C)
11	63	2030	60,215	(C)
12	63	2365	60,115	(C)
13	63	1188	59,220	(C)
14	64	4262	60,354	(C)
15	65	2755	57,533	(C)
16	66	2419	58,540	(C)
17	67	3675	58,040	(C)
18	67	3285	62,176	(C)
19	68	500	63,595	(C)
20	69	745	58,339	(C)
21	70	4438	54,001	(C)
22	71	1620	60,991	
23	72	994	60,738	
24	73	1501	72,640	
25	74	4366	70,368	
26	75	729	62,245	


M113 Armor Personnel Carrier
CONSTANT DOLLARS (000's)
CONTRACT AWARD
COMPETITIVE AWARDS
SOLE SOURCE AWARDS
130
120
110
100
90
80
70
60
50
1 2 3 4 5 6 7 8 9 10 1 2 3 4 5 6 7 8 9 20 1 2 3 4 5 6

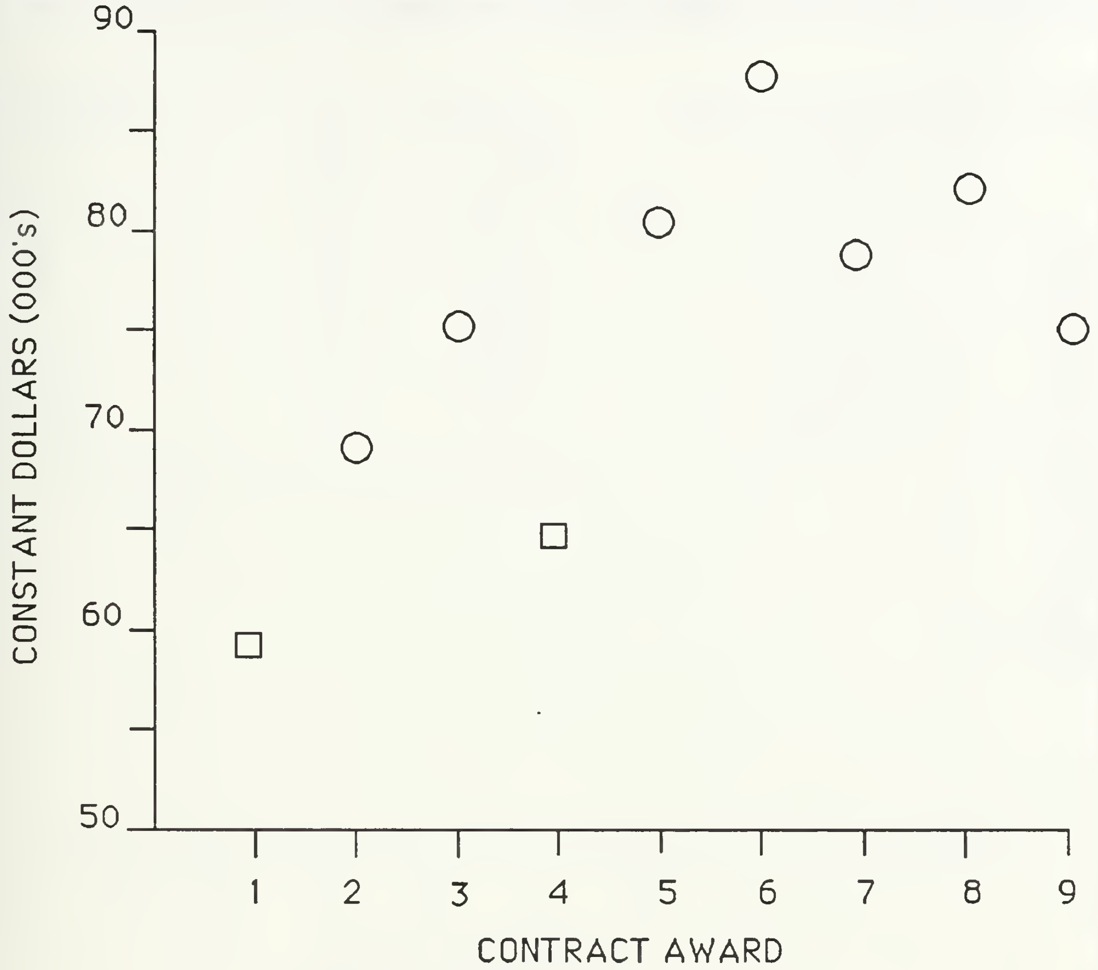


M106 SELF PROPELLED MORTAR

CONTRACT	FY	QTY	DEC 80 CONSTANT DOLLARS
1	63	840	36,504 (C)
2	64	640	69,211
3	65	28	56,985 (C)
4	67	152	66,833
5	69	302	60,290 (C)
6	72	1	91,125
7	73	24	97,022

□ COMPETITIVE AWARDS

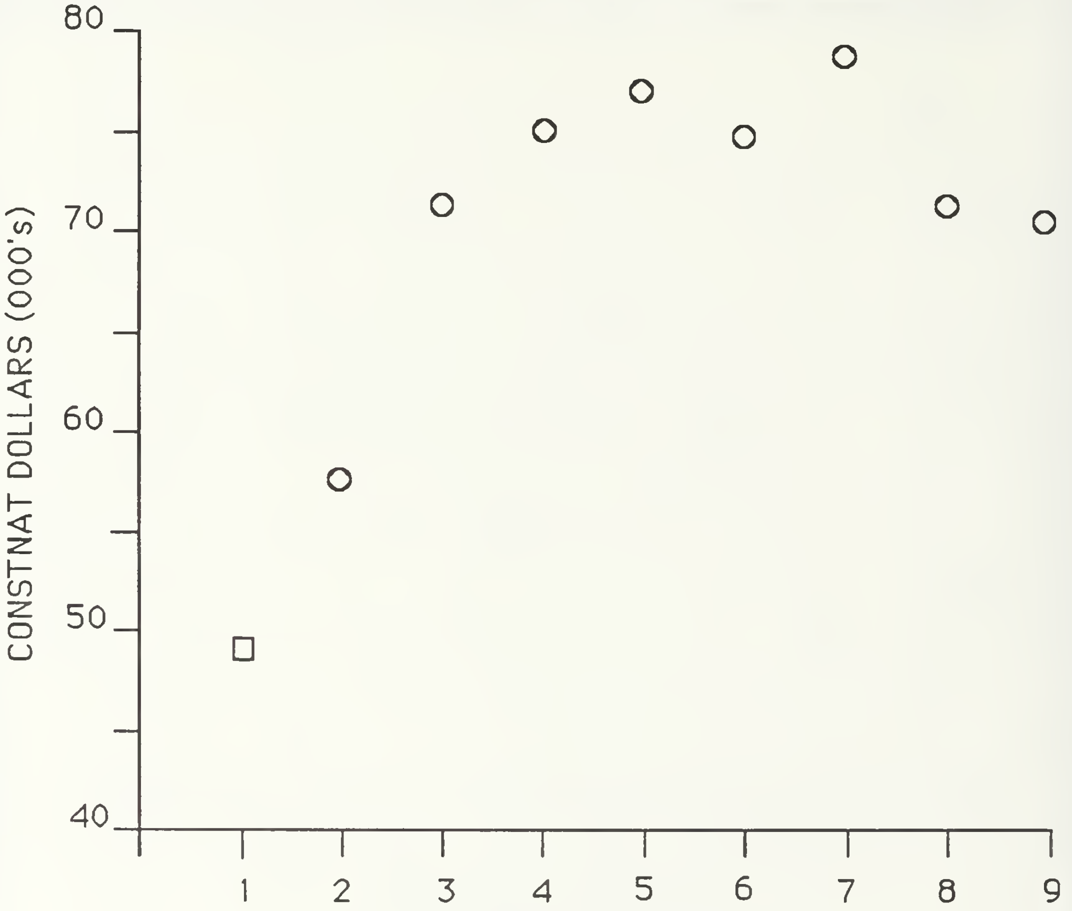
○ SOLE SOURCE AWARDS



M125 SELF PROPELLED MORTAR

CONTRACT	FY	QTY	DEC 80 CONSTANT DOLLARS	
1	65	363	59,589	(C)
2	67	509	68,970	
3	67	95	75,840	
4	69	202	63.888	(C)
5	72	45	80,919	
6	74	687	88,029	
7	75	33	79,673	
8	76	30	82,519	
9	77	69	75,080	

□ COMPETITIVE AWARDS
○ SOLE SOURCE AWARDS



CONTRACT AWARD

M548 CARGO CARRIER

CONTRACT	FY	QTY	DEC 80 CONSTANT DOLLARS	
1	65	2455	48,723	(C)
2	67	507	57,000	
3	67	412	71,103	
4	67	120	75,191	
5	73	285	76,578	
6	73	188	75,368	
7	74	116	78,543	
8	76	64	71,691	
9	77	275	70,989	

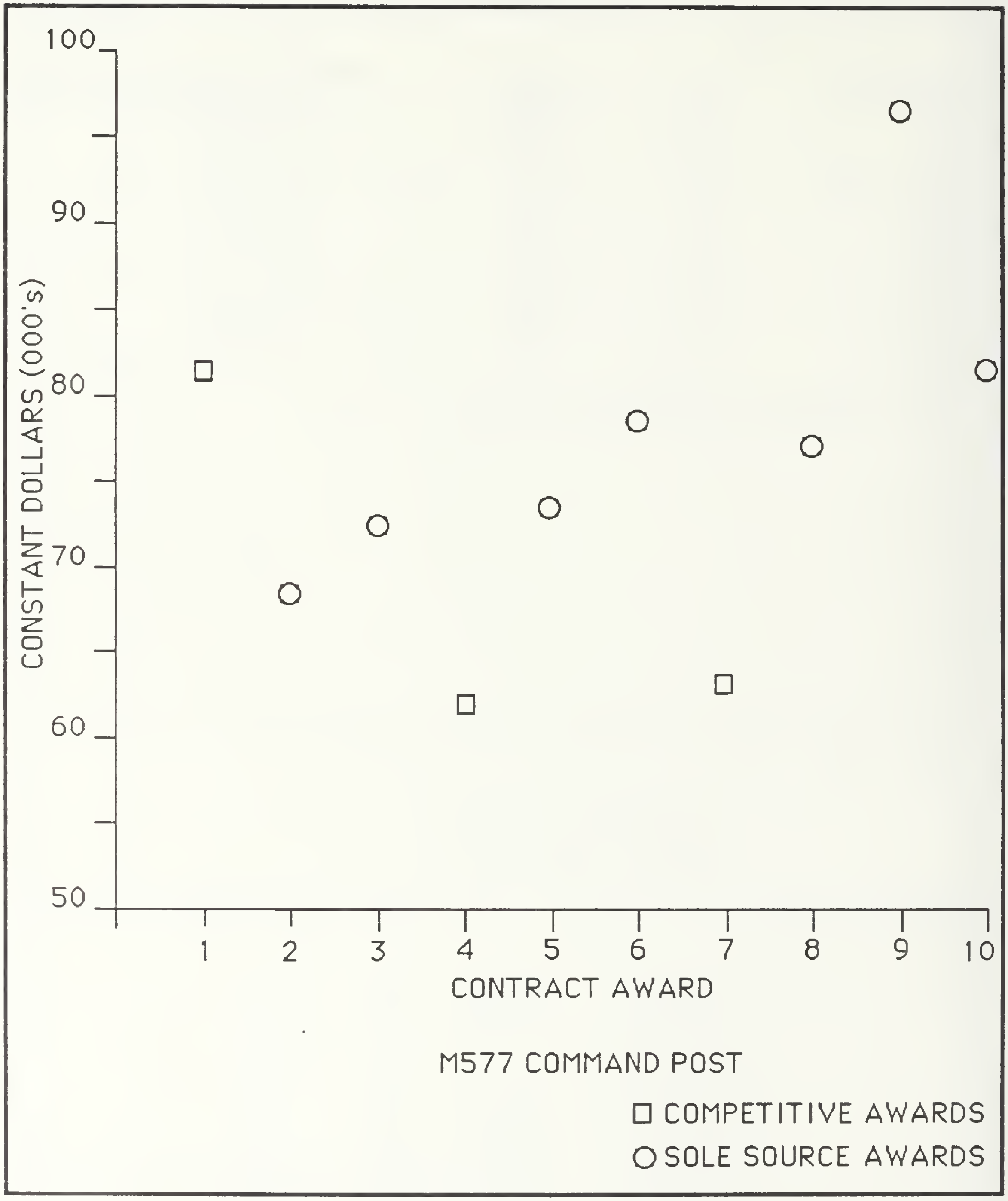
□ COMPETITIVE AWARDS

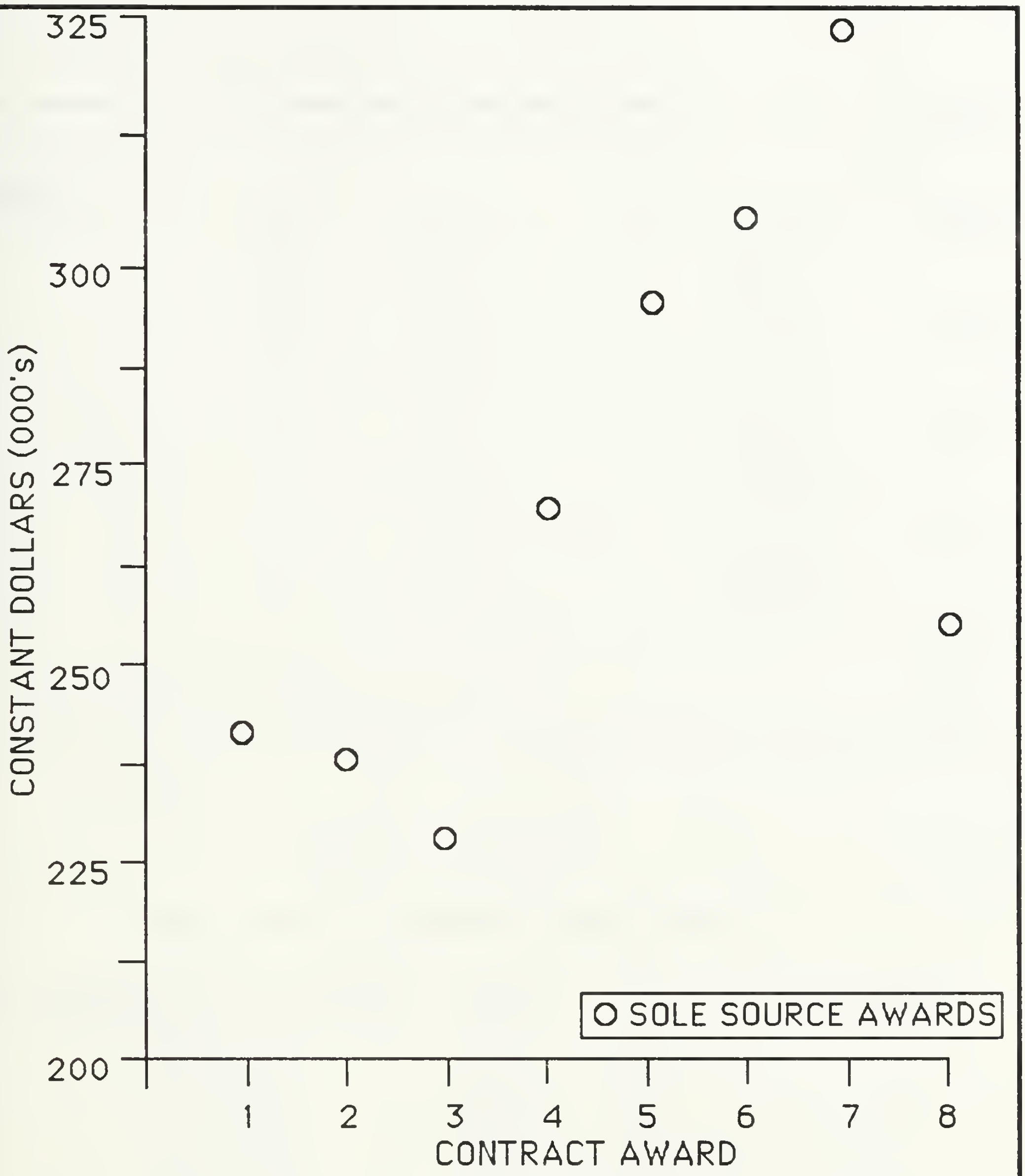
○ SOLE SOURCE AWARDS

M577 COMMAND POST

CONTRACT	FY	QTY	DEC 80 CONSTANT DOLLARS	
1	62	270	82,473	(C)
2	63	674	67,804	
3	64	1225	72,596	
4	65	557	62,783	(C)
5	67	216	73,673	
6	67	205	79,464	
7	69	662	63,669	(C)
8	72	241	77,153	
9	73	308	96,368	
10	74	59	86,190	

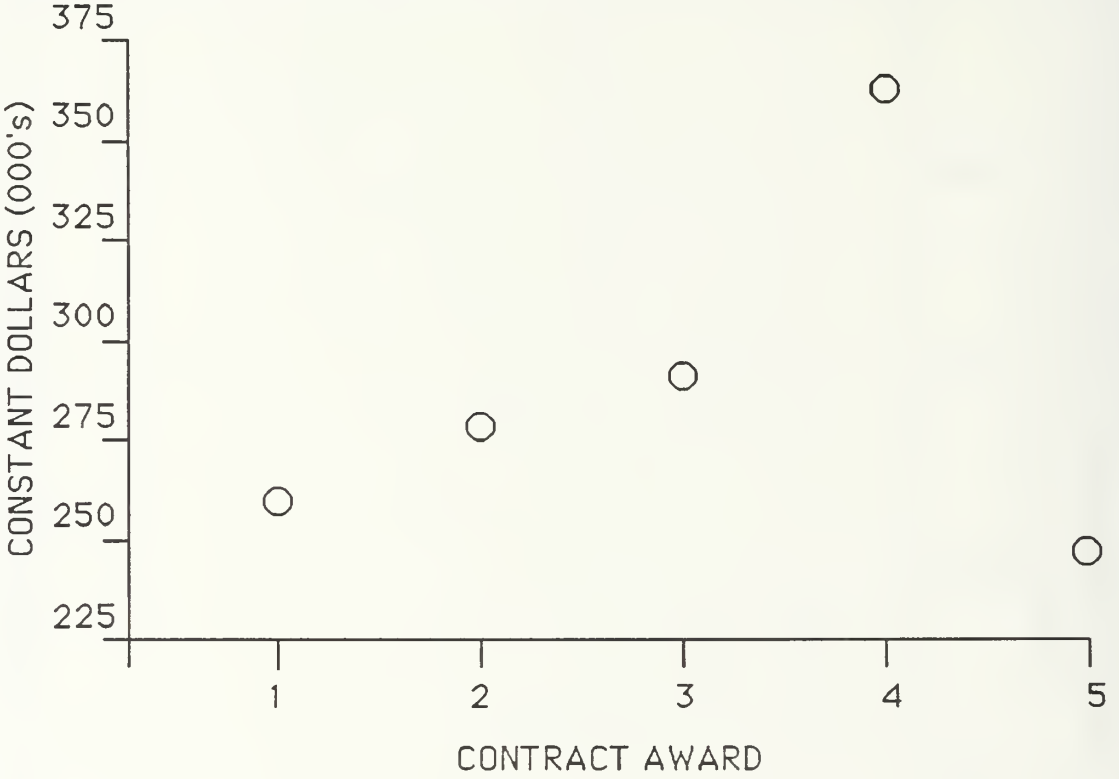
(C) denotes Competitive Award


100
90
80
70
60
50
CONSTANT DOLLARS (000's)
1
2
3
4
5
6
7
8
9
10
CONTRACT AWARD
M577 COMMAND POST
COMPETITIVE AWARDS
SOLE SOURCE AWARDS



M109A1B Self Propelled Artillery

CONTRACT	FY	QTY	DEC 80 CONSTANT DOLLARS
1	72	20	239,031
2	73	91	234,977
3	74	366	227,045
4	76	134	270,986
5	77	94	296,228
6	78	17	305,157
7	79	218	322,455
8	80	207	258,211



M109A2 SELF PROPELLED ARTILLERY

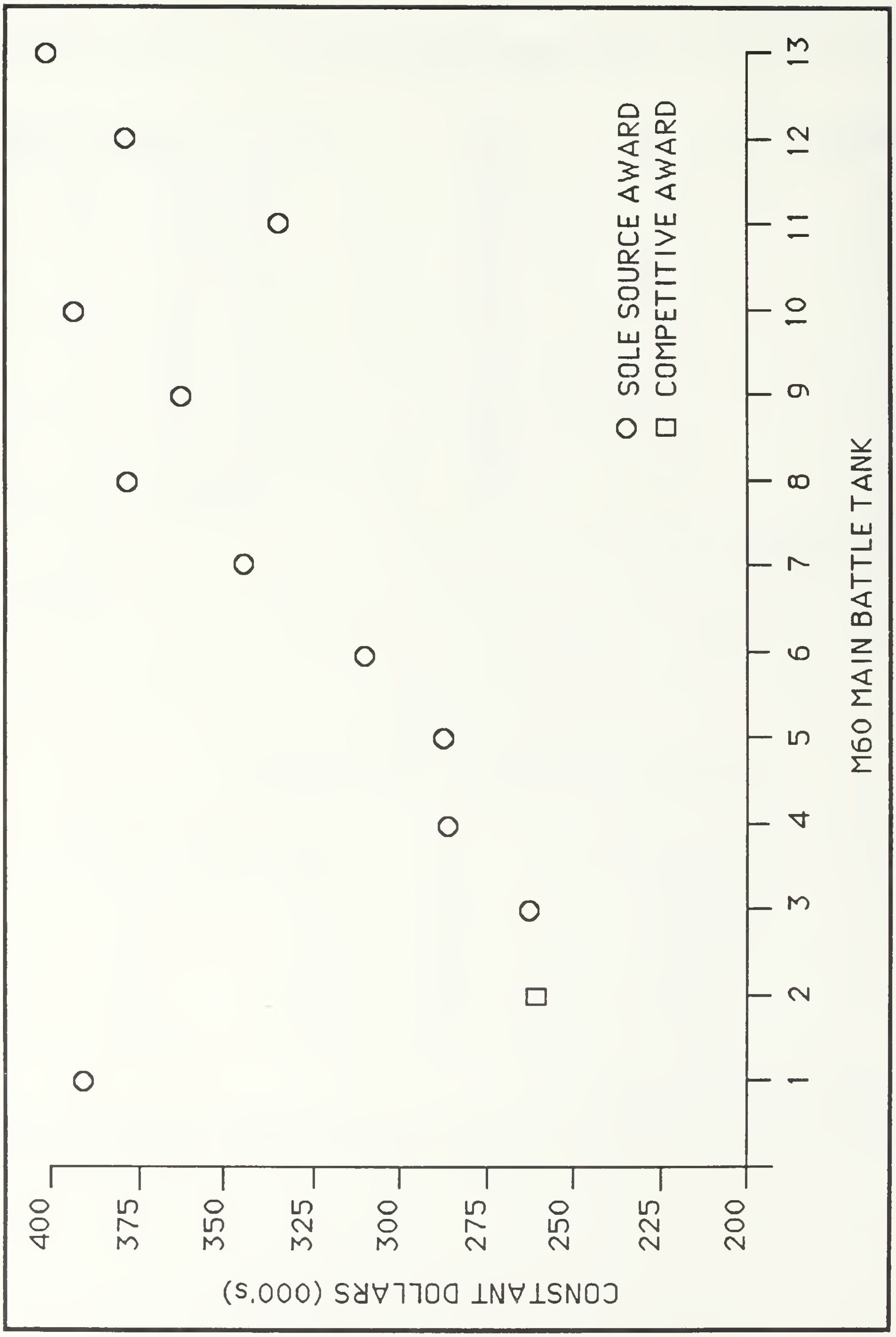
CONTRACT	FY	QTY	DEC 80 CONSTANT DOLLARS
1	76	12	259,295
2	77	353	277,257
3	78	267	293,902
4	79	242	361,773
5	80	187	247,839

○ SOLE SOURCE AWARDS

M60 MAIN BATTLE TANK

CONTRACT	FY	QTY	DEC 80 CONSTANT DOLLARS	
1	59	360	386,990	
2	60	885	268,775	(C)
3	64	360	269,654	
4	65	246	282,817	
5	66	314	283,172	
6	67	300	311,345	
7	69	117	345,065	
8	70	300	376,640	
9	71	450	366,189	
10	72,73	338	388,205	
11	74	480	331,531	
12	75	1240	376,162	
13	76	1201	400,998	

(C) denotes Competitive Award


CONSTANT DOLLARS (000's)
400
375
350
325
300
275
250
225
200
1
2
3
4
5
6
7
8
9
10
11
12
13
M60 MAIN BATTLE TANK
SOLE SOURCE AWARD
COMPETITIVE AWARD

APPENDIX C

ANALYSIS OF THE COMPETITIVE PRODUCTION OF THE AAAV

CONTRACT TEAMING STRATEGY

This analysis makes the following assumptions:

1. That a Contract Teaming strategy was employed during development with the result that production competition began with the first year of production.

2. That 1500 vehicles will be produced over a four year period, with production quantities being 200, 500, 500, and 300 respectively, with a first unit cost of $3,867,225 for each contractor.

3. That the minimum sustaining rate has been determined to be 30% of production and that the maximum production award will be 70% of the yearly rate. Bids will be accepted from two production sources using the "Minimum Total Cost" rule with bids being given for all production quantities for 30% through 70% of yearly production.

4. The first unit price for both contractors is the same.

5. Once a contractor is assigned a progress curve the slope will not change throughout the four year production. In addition once a lead source is establish (that source with the steeper progress curve), and a competitive source is established (that source with the shallower progress curve), that this relationship remains the same for the four year production. This means that the competitive source will never become the lead source, or vice versa, but will continue production of the specified minimum sustaining rate, i.e. 40%, for the four year production.

6. That the forecast savings are the difference in total production cost between the hypothetical sole source production of 1500 vehicles utilizing his assigned progress curve, and the total production cost of two competitive contractors utilizing their assigned progress curves.

7. That no amount has been utilized in the calculations to allow for the costs of establishing the second source or in managing the increased size of the program.

8. That no variable for production rate has been introduced, either to allow for additional learning or to allow for inefficiencies due to economy of scale.

PROGRESS CURVES

HYPOTHETICAL SOLE SOURCE	LEAD SOURCE	COMPETITIVE SOURCE
1.0	.995	.995

PRODUCTION SPLIT	TOTAL PRODUCTION COST	TOTAL PRODUCTION SAVINGS
50/50	5,539,883,113	260,954,387
60/40	5,539,074,574	261,762,926
70/30	5,536,577,668	264,259,832

HYPOTHETICAL SOLE SOURCE	LEAD SOURCE	COMPETITIVE SOURCE
1.0	.99	.99

PRODUCTION SPLIT	TOTAL PRODUCTION COST	TOTAL PRODUCTION SAVINGS
50/50	5,318,213,664	482,623,836
60/40	5,316,668,460	484,169,040
70/30	5,311,895,078	488,942,422

HYPOTHETICAL SOLE SOURCE	LEAD SOURCE	COMPETITIVE SOURCE
1.0	.97	.99

PRODUCTION SPLIT	TOTAL PRODUCTION COST	TOTAL PRODUCTION SAVINGS
50/50	4,913,964,766	886,872,734
60/40	4,818,065,632	982,771,868
70/30	4,717,040,893	1,083,796,607

HYPOTHETICAL SOLE SOURCE	LEAD SOURCE	COMPETITIVE SOURCE
1.0	.88	.91

PRODUCTION SPLIT	TOTAL PRODUCTION COST	TOTAL PRODUCTION SAVINGS
50/50	2,394,106,837	3,406,730,663
60/40	2,323,100,168	3,477,737,332
70/30	2,238,526,063	3,562,311,437

HYPOTHETICAL SOLE SOURCE	LEAD SOURCE	COMPETITIVE SOURCE
.97	.97	.97

PRODUCTION SPLIT	TOTAL PRODUCTION COST	TOTAL PRODUCTION SAVINGS
50/50	4,509,715,868	(113,899,506)
60/40	4,505,860,091	(110,043,729)
70/30	4,493,933,310	(98,116,948)

HYPOTHETICAL SOLE SOURCE	LEAD SOURCE	COMPETITIVE SOURCE
.97	.96	.96

PRODUCTION SPLIT	TOTAL PRODUCTION COST	TOTAL PRODUCTION SAVINGS
50/50	4,148,877,705	246,938,657
60/40	4,144,195,721	251,620,641
70/30	4,129,703.477	266,112,885

HYPOTHETICAL SOLE SOURCE	LEAD SOURCE	COMPETITIVE SOURCE
.97	.94	.96

PRODUCTION SPLIT	TOTAL PRODUCTION COST	TOTAL PRODUCTION SAVINGS
50/50	3,826,837,100	568,979,262
60/40	3,750,118,078	645,982,284
70/30	3,662,690,753	733,125,609

HYPOTHETICAL SOLE SOURCE	LEAD SOURCE	COMPETITIVE SOURCE
.97	.91	.93

PRODUCTION SPLIT	TOTAL PRODUCTION COST	TOTAL PRODUCTION SAVINGS
50/50	2,963,116,366	1,432,699,996
60/40	2,902,438,910	1,493,377,452
70/30	2,828,578,171	1,567,238,191

HYPOTHETICAL SOLE SOURCE	LEAD SOURCE	COMPETITIVE SOURCE
.97	.88	.91

PRODUCTION SPLIT	TOTAL PRODUCTION COST	TOTAL PRODUCTION SAVINGS
50/50	2,394,106,837	2,001,709,525
60/40	2,323,100,168	2,072,716,194
70/30	2,238,526,063	2,157,290,299

HYPOTHETICAL SOLE SOURCE	LEAD SOURCE	COMPETITIVE SOURCE
.94	.94	.94

PRODUCTION SPLIT	TOTAL PRODUCTION COST	TOTAL PRODUCTION SAVINGS
50/50	3,504,796,494	(193,317,227)
60/40	3,498,988,990	(187,509,723)
70/30	3,480,987,736	(169,508,469)

HYPOTHETICAL SOLE SOURCE	LEAD SOURCE	COMPETITIVE SOURCE
.94	.93	.93

PRODUCTION SPLIT	TOTAL PRODUCTION COST	TOTAL PRODUCTION SAVINGS
50/50	3,218,176,263	93,303,004
60/40	3,212,024,393	99,454,874
70/30	3,192,941,957	118,537,310

HYPOTHETICAL SOLE SOURCE	LEAD SOURCE	COMPETITIVE SOURCE
.94	.925	.925

PRODUCTION SPLIT	TOTAL PRODUCTION COST	TOTAL PRODUCTION SAVINGS
50/50	3,083,030,633	228,448,634
60/40	3,076,752,423	234,726,844
70/30	3,057,270,954	254,208,313

HYPOTHETICAL SOLE SOURCE	LEAD SOURCE	COMPETITIVE SOURCE
.94	.91	.93

PRODUCTION SPLIT	TOTAL PRODUCTION COST	TOTAL PRODUCTION SAVINGS
50/50	2,963,116,366	348,362,901
60/40	2,902,438,910	409,040,357
70/30	2,828,578,171	482,901,096

HYPOTHETICAL SOLE SOURCE	LEAD SOURCE	COMPETITIVE SOURCE
.94	.88	.91

PRODUCTION SPLIT	TOTAL PRODUCTION COST	TOTAL PRODUCTION SAVINGS
50/50	2,394,106,837	2,001,095,525
60/40	2,323,100,168	2,072,716,194
70/30	2,238,526,063	2,157,290,299

HYPOTHETICAL SOLE SOURCE	LEAD SOURCE	COMPETITIVE SOURCE
.91	.91	.91

PRODUCTION SPLIT	TOTAL PRODUCTION COST	TOTAL PRODUCTION SAVINGS
50/50	2,708,056,469	(230,177,123)
60/40	2,701,556,389	(223,677,043)
70/30	2,681,363,776	(203,484,430)

HYPOTHETICAL SOLE SOURCE	LEAD SOURCE	COMPETITIVE SOURCE
.91	.89	.89

PRODUCTION SPLIT	TOTAL PRODUCTION COST	TOTAL PRODUCTION SAVINGS
50/50	2,272,840,720	205,038,626
60/40	2,266,340,388	211,538,958
70/30	2,246,115,560	231,763,786

HYPOTHETICAL SOLE SOURCE	LEAD SOURCE	COMPETITIVE SOURCE
.91	.88	.91

PRODUCTION SPLIT	TOTAL PRODUCTION COST	TOTAL PRODUCTION SAVINGS
50/50	2,280,947,661	196,931,685
60/40	2,233,518,353	244,360,993
70/30	2,172,442,823	305,436,523

APPENDIX D

LIST OF ABBREVIATIONS

AAV	Amphibian Assault Vehicle
AAAV	Advanced Amphibian Assault Vehicle
AAWS-M	Advanced Anti-Tank Weapon System-Medium
APC	Armor Personnel Carrier
APRO	Army Procurement Research Office
ASPJ	Airborne Self-Protection Jammer
ATA	Advanced Tactical Aircraft
ATF	Advanced Tactical Fighter
BFV	Bradley Fighting Vehicle
CE	Concept Exploration
CICA	Competition In Contracting Act
CT	Contractor Teaming
DAB	Defense Acquisition Board
DCAS	Defense Contract Administration Service
DFAR	Defense Federal Acquisition Regulations
DL	Direct Licensing
DLSIE	Defense Logistics Studies Information Exchange
DOD	Department of Defense
DODI	Department of Defense Instruction
DT	Demonstration Testing
DTC	Design to Cost
DTIC	Defense Technical Information Exchange

D&V	Demonstration and Validation
ECP	Engineering Change Proposal
F3	Form, Fit, and Function
FAR	Federal Acquisition Regulation
FSD	Full Scale Development
FY	Fiscal Year
GAO	Government Accounting Office
GFE	Government Furnished Equipment
GPLR	Government Purpose License Rights
IOC	Initial Operating Capability
IDA	Institute of Defense Analysis
INEWS	Integrated Electronic Warfare System
LCCE	Life Cycle Cost Estimate
LF	Leader-Follower
MBT	Main Battle Tank
MRV	Mission Role Variant
OT	Operational Testing
PIC	Price Improvement Curve
PTLD	Physical Teardown Logistics Demonstration
RFP	Request for Proposal
SLEP	Service Life Extension Program
SSMSM	Second Source Method Selection Model
TDP	Technical Data Package

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